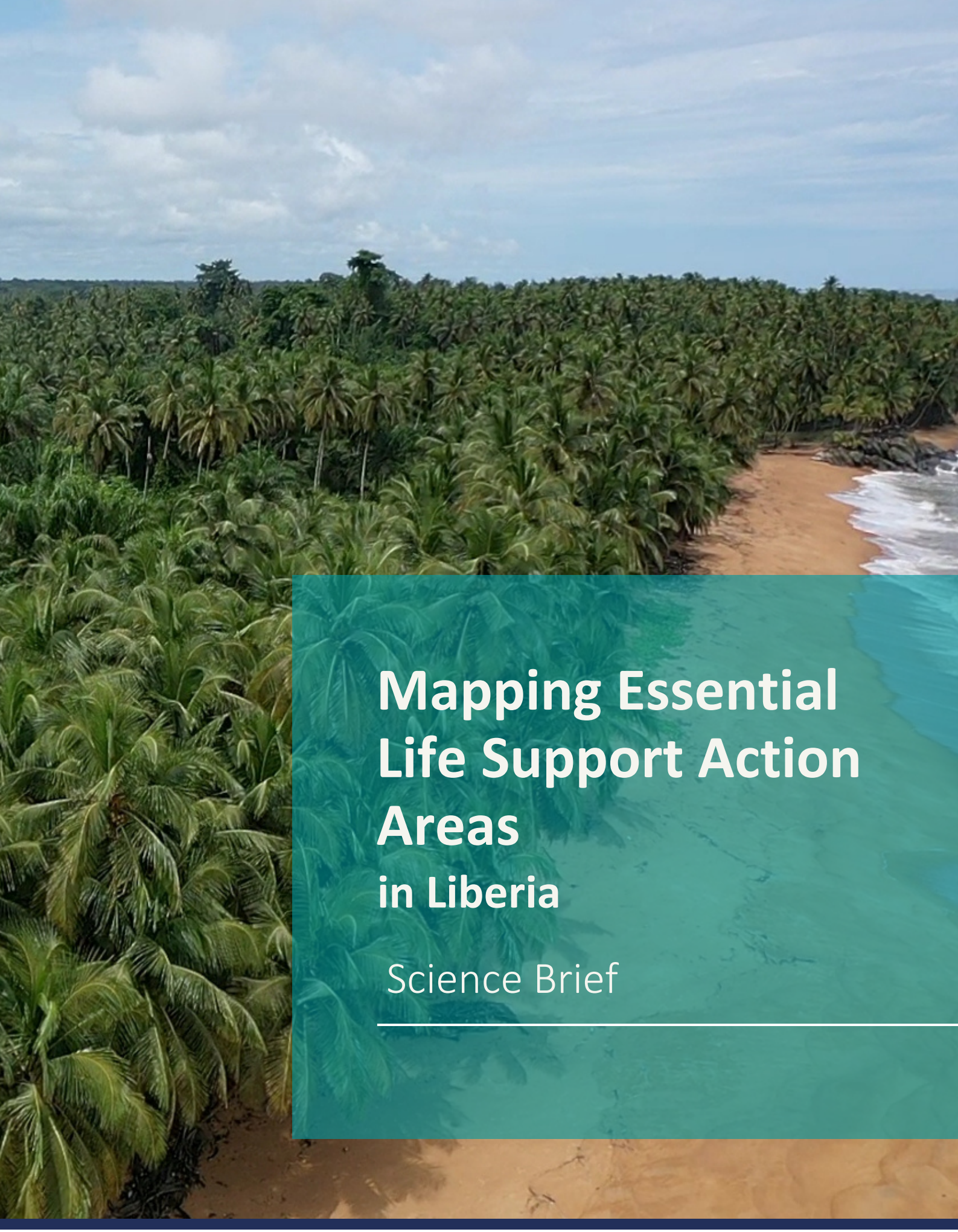

Mapping Essential Life Support Action Areas
in Liberia

Science Brief

EPA

Sida

UNDP

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Executive Summary

This brief aims to provide a concise summary of the science behind the Essential Life Support Area (ELSA) map and online webtool for Liberia. The ELSA map and webtool have been developed through the Mapping Nature for People and Planet project in Liberia.

Chapter 1 of this science brief provides background information on the ELSA process in Liberia. Chapter 2 describes the science behind ELSA and elucidates how the process can contribute to the nation's priorities by creating an action map that shows where protecting, managing, and restoring nature, along with urban greening, can lead to optimal impacts across key policy commitments. For further information using ELSA webtool, please refer to the ELSA Webtool User Guide.


Photo by Bethany Laird on Unsplash

Introduction: Essential Life Support Areas (ELSAs)—what and why

Background

Maintaining a healthy planet where people and ecosystems thrive requires reliable, timely, decision-relevant information. While the number of global, biodiversity-based information sources grows daily, few are accessible and curated to meet the needs of policymakers at the national scale. A user needs assessment of 60 Parties to the Convention on Biological Diversity (CBD) conducted by the United Nations Development Programme (UNDP) in 2018 identified four significant barriers to integration of spatial data into national policy:

1. Spatial data is inaccessible,
2. Spatial data is unusable,
3. Spatial data is not nationally validated, and
4. Governments lack the capacity to use spatial data.

To put it simply, although earth observations are available that have potential to support implementation of the Sustainable Development Goals (SDGs), countries are not utilizing them. This 'data gap' takes a toll on national efforts to safeguard nature and related ecosystem services.

The Endeavor: Mapping Nature for People and Planet

The Mapping Nature for People and Planet Partnership brings together scientists and policy experts to harness earth observations to deliver on national priorities. To do this, the partnership works closely with countries to identify their essential life support areas (ELSAs), defined as areas where nature-based actions can safeguard key biodiversity and ecosystem services. Nature-based actions refer to land and sea management that address the biodiversity crisis, climate crisis, and promote sustainable development. These actions can include the protection, management, and/or restoration of ecosystems.

The partnership has created a scientific framework and decision support system to bring together national data in a central repository, to identify ELSAs that show where nature-based actions should be taken based on national priorities, and to monitor the impact of these actions. Our theory of change is that map-based, credible, high-quality information combined with capacity building at the national level will drive shifts in policy implementation and reporting to deliver on the 2030 Agenda and the Rio Conventions.

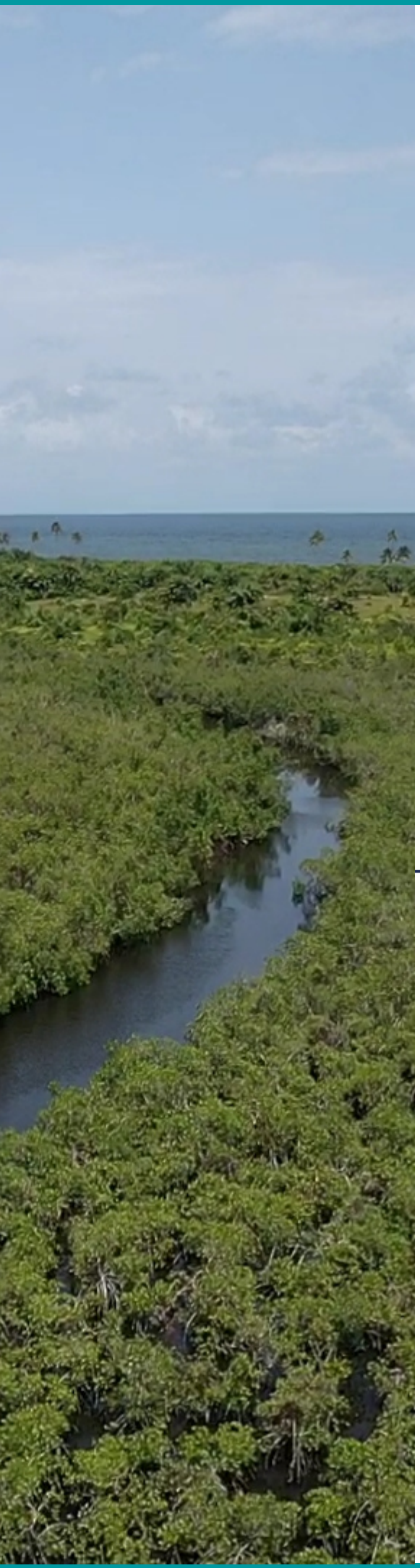
The project has supported Liberia to:

1. Consolidate national data to create a national repository of spatial data on biodiversity and ecosystem services;
2. Apply rigorous scientific methodology to create a systematic conservation planning tool to identify ELSAs; and
3. Use earth observations to monitor and report on progress towards achieving the 2030 Agenda and other key international commitments.

Project outcomes will be added to Liberia's secure workspace on the UN Biodiversity Lab, an UN-supported platform that provides countries with access to the best global and national spatial data on biodiversity, ecosystem services, and sustainable development. To request access to Liberia's workspace, please contact Berexford Jallah (bjallah2@outlook.com) and Love Allison (loveallison55295@gmail.com). The successful approaches developed in Liberia will inform the further development of the ELSA project in other pilot countries.

The Partnership

Working with Liberia, Cambodia, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, Kazakhstan, Nepal, Peru, South Africa, and Uganda as the 12 initial pilot countries, this work brings together a powerful coalition of governments, NGOs, research institutes, and intergovernmental organizations.



The Liberia case:
In Liberia, the project is led by the United Nations Development Programme (UNDP) and the University of Northern British Columbia (UNBC) with funding from the Swedish International Development Cooperation Agency (Sida).Technical support is provided by the Pacific Marine Analysis and Research Association (PacMARA) and the Impact Observatory.

Participating institutions include: Liberia's Environmental Protection Agency (EPA), Ministry of Agriculture, Ministry of Finance and Development Planning, Ministry of Information Culture and Tourism, Ministry of Mines and Energy, Ministry of Transport, National Fisheries and Aquaculture Authority, Liberia Maritime Authority, Liberia Land Authority, Liberia Statistics and Geo-information Services, University of Liberia, Farmers Association for Conservation of the Environment, Society for Conservation of Nature in Liberia, Environmental Justice Foundation, EPA/NDC Partnership, Forestry Development Authority (FDA), Conservation International (CI)-Liberia, Liberian Hydrological Service (LHS/MME) , among others.

Quick Resources on ELSA(A)

Introduction to ELSA

- ELSA trailer: This 4-minute introductory video explains the basics of mapping ELSAs and tours the world to explore how different countries are applying the ELSA process.
- ELSA brochure: This 8-page polished publication provides an introduction to ELSA and how countries around the world are using the ELSA process.
- Monitoring ELSAs using dynamic data: This 2-minute presentation introduces new high-resolution land use land cover data that can help to monitor progress towards a country's priority policy commitments.
- ELSA vision: This 8-minute video elucidates the foundation and goals of the ELSA methodology.
- ELSA recipe: This 12-minute video provides an overview of the 10-steps of the ELSA approach.

Science of ELSA

- Training on Systematic Conservation Planning: This session offered by PacMARA to South Africa scientists and leaders introduces the fundamentals of the science behind ELSA, Systematic Conservation Planning.
- Training on prioritizr: Further information is available from the prioritizr website and the prioritizr workshop manual.
- Data included in South Africa ELSA analysis: This presentation slides describes the pre-processing of the datasets included in the second ELSA map for South Africa.
- Development of Liberia's second ELSA map (Day 2 | Day 3): These recordings show the interactive co-creation of Liberia's second ELSA map.

ELSA in Liberia

Workshops:

- First workshop website
- First workshop report
- Second workshop website
- Second workshop report

ELSA in Other Countries

- Learning for Nature ELSA Community of Practice
- Costa Rica project overview (EN) and solution video (EN)
- Kazakhstan project overview (EN) and solution video (EN)
- Uganda project overview (EN) and solution video (EN)
- Colombia project overview (SP | EN subtitles) and solution video (EN)
- Dominican Republic solution video (SP | EN subtitles)
- Ecuador solution video (SP | EN subtitles)
- Cambodia solution video (EN)
- South Africa solution video (EN)

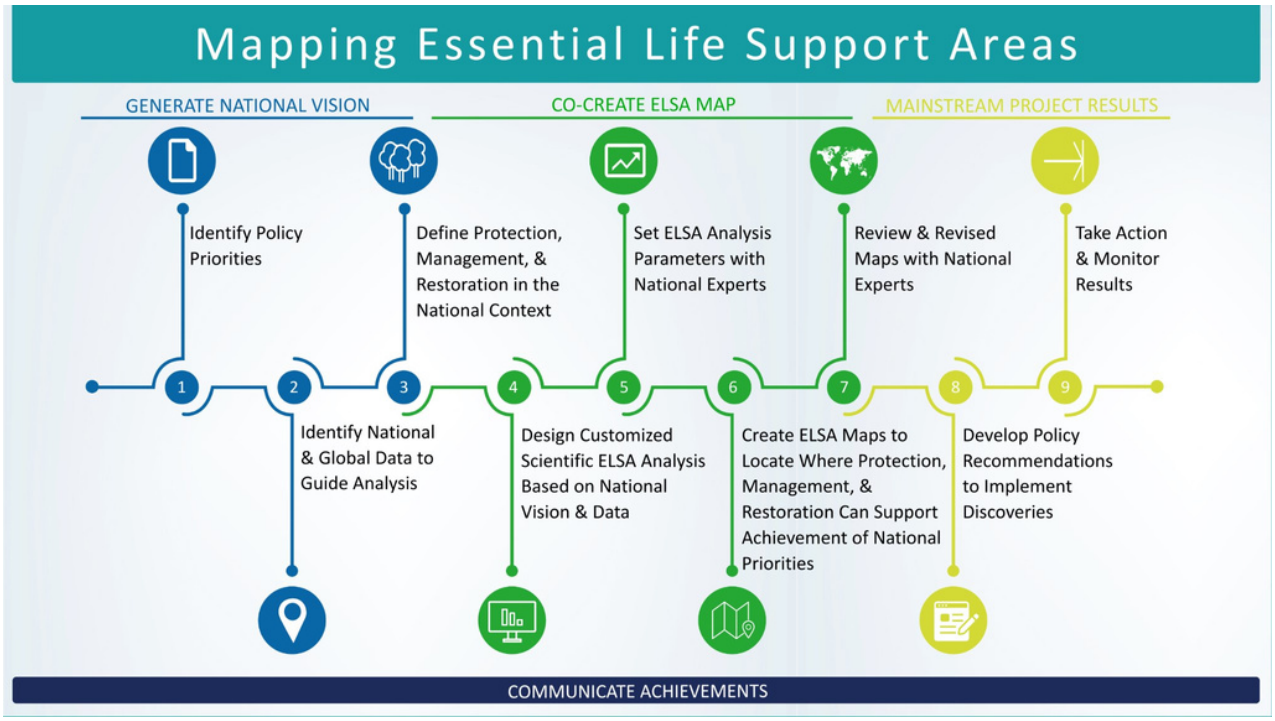
The Science of ELSA

Overview of the ELSA Process

In order to identify key nature-based actions that can support priority policy commitments in Liberia, the ELSA process includes four broad areas of work: (1) Identify priority policy commitments; (2) Collect national and global data to map these commitments; (3) Produce ELSA action maps, or 'maps of hope', that create a roadmap to achieve the key commitments; (4) Inform national decision making, implementation, and reporting.

These four areas of work are composed of nine steps, as well as an overarching focus on communication throughout the project. In Liberia, stakeholders worked together to execute the nine steps of the ELSA process, with a continued focus on steps 8 and 9 on policy development and implementation & monitoring, as well as on communication (Figure 1).

FIGURE 1. THE ELSA PROCESS



Methods Used to Create the ELSA Map

- The policy: How does each country identify its priority policy commitments?

ELSA uses spatial data as a tool to identify where nature-based actions will have maximum impact for biodiversity, climate change, and sustainable development across a country's most critical policy commitments. To do this, the Mapping Nature for People and Planet partnership core team first identifies: (1) the most important nature-based policy commitments in each country (Figure 1, Step 1), and (2) the nature-based actions endorsed as policy solutions (Figure 1, Step 3). These are both determined through an extensive stakeholder engagement process.

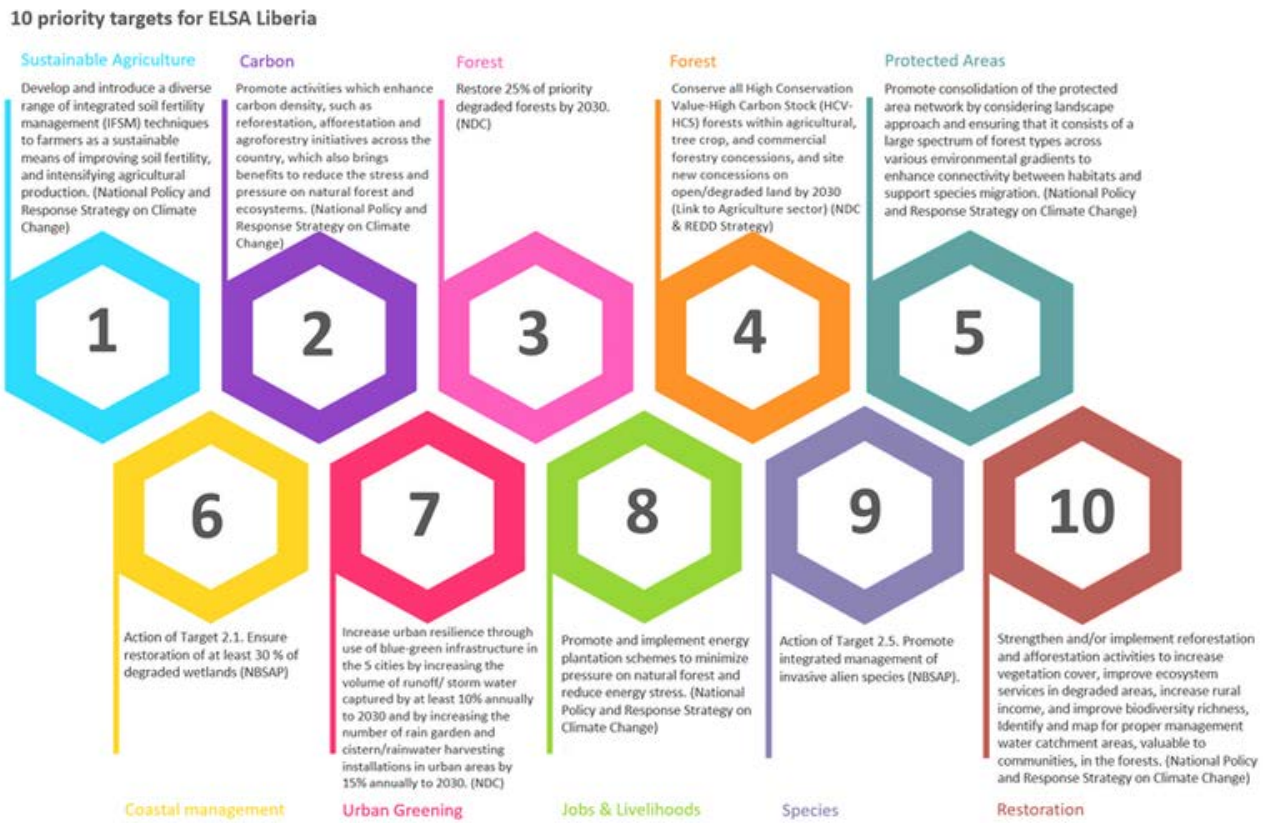
1. Identification of nature-based policy commitments. First, the core team identifies up to ten central policy documents they would like to guide the ELSA process. These documents might include the full scope of the country's priorities for biodiversity, climate change, and sustainable development, or a country might choose to focus on a particular project or plan or interest, such as water security. The core team then conducts a rapid policy analysis to identify the nature-based commitments (priority commitments) within these policies. Finally, during the first project workshop, the project core team works with a diverse group of national stakeholders to survey these nature-based commitments, determine which can be mapped using spatial data, and identify up to 10 that are most critical for the nation's strategic priorities.
2. Identification of nature-based actions. The nature-based actions used in the ELSA analysis are actions to protect, manage, and restore natural ecosystems, and urban greening. The ELSA analysis will determine the best place for each of these actions to be implemented to support the achievement of the 10 priority policy commitments. Each nature-based action is defined in consultation with national stakeholders to provide a clear picture of how it is conceived and implemented in a given country.

In addition, an area-based target for each nature-based action is identified based on existing policy commitments. These area-based targets provide a key input into the ELSA analysis by setting the amount of land area the analysis can recommend for protection, restoration, management, and urban greening to contribute to the achievement of the 10 priority policy commitments.

The ELSA Policy Priorities in Liberia

In Liberia, ten priority policy commitments were initially identified. They are shown in Figure 2. The selected policy commitments span sustainable agriculture, protected areas, coastal management, urban greening, restoration, species and ecosystems, and human well-being.

FIGURE 2. PRIORITY COMMITMENTS IDENTIFIED THROUGH STAKEHOLDER CONSULTATION IN LIBERIA



The ELSA Nature-based Actions in Liberia

Liberia chose to focus their ELSA analysis on actions to protect, manage, and restore natural ecosystems, as well as urban greening. National stakeholders additionally highlighted that within these broad classes of nature-based solutions, it was incredibly important to take in mind the underlying food insecurity and poverty in the country. They highlighted that any action must consider this reality and offer support for rural livelihoods and food production. Long discussions also highlighted the importance of increasing the protection actions in the country, with a minimum threshold of protected areas of 30%.

The area-based targets used in the analysis are equal to existing policy commitments. This enables the final ELSA map to indicatively suggest areas for each nature-based action that can be discussed with local stakeholders rather than prescriptively determining a specific course of action.

The final definitions and area-based targets are summarized in Table 1.

- The data: How does each country identify relevant spatial data for the ELSA analysis?

Based on the outcomes of the policy process, the core team works together to identify the best global and national data that can: (1) serve as a proxy for the priority policy commitments (Figure 1, Step 2) and (2) constrain the zones where each nature-based action can take place in the country (Figure 1, Step 3).

1. Data to Map Priority Policy Commitments. The core team evaluates each of the policy commitments to identify spatial datasets that can serve as a 'proxy' by mapping the commitment in the analysis. These spatial proxy data sets are known as planning features. Depending on the complexity of the commitment, it might correspond to one or multiple planning features. The analysis will ultimately seek to optimize outcomes across all planning features.

For example, when looking at a policy commitment for biodiversity, the core team might map this commitment through planning features such as ecosystem connectivity and integrity, threatened species distribution, species richness, and Key Biodiversity Areas. These planning features will be used in the analysis in combination with planning features for commitments related to climate change, water security, food security, and sustainable livelihoods.

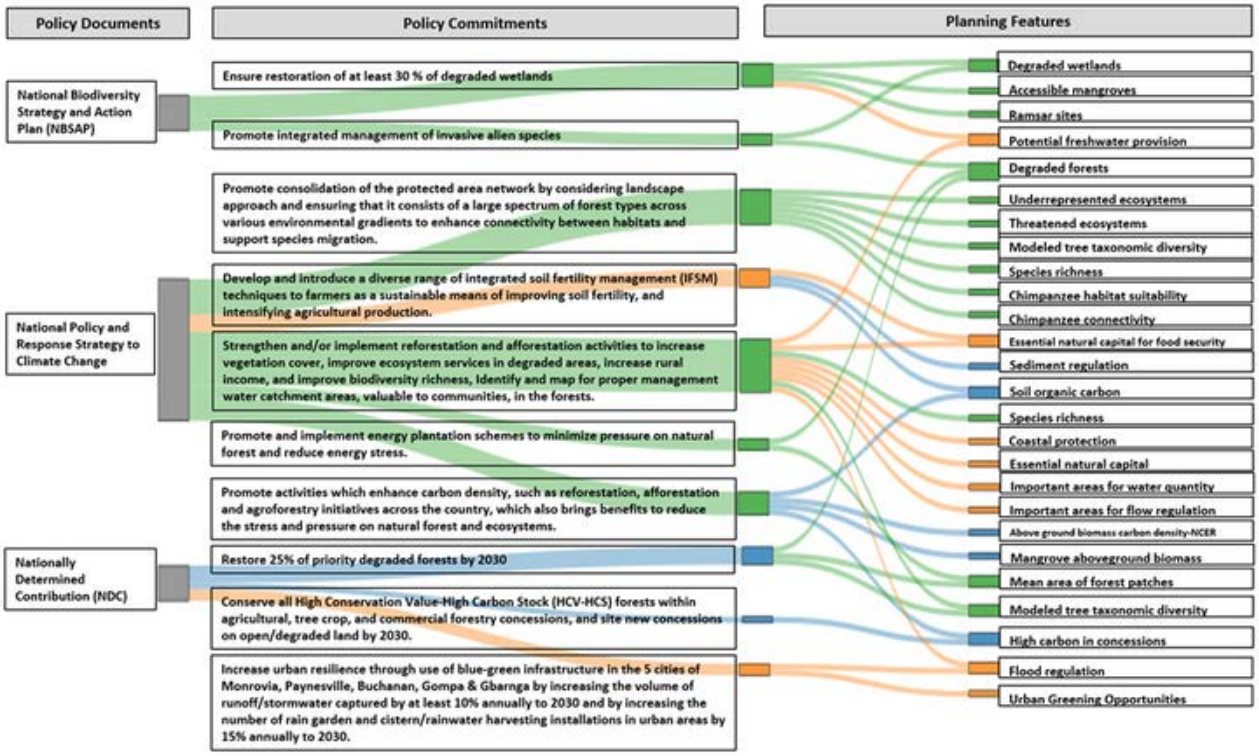
2. Data to Map Zones. Zones determine where each nature-based action can be implemented according to the land capacity and political zoning of the country. These zones are created based on "rules", or constraints, that help the algorithm to identify viable locations for each action. For example, zoning constraints might tell the algorithm that protection can take place in areas where ecosystem quality is high, human pressure is low, and government zoning allows the allocation of a protected area.

Together, these data provide the key inputs needed to run the ELSA analysis (Figure 1, Steps 4-7).

Mapping of Priority Policy Commitments in Liberia

Twenty-six planning features were identified that could serve as spatial proxies for the ten policy commitments selected by Liberia. The relationship between the policy commitments and planning features is shown in Figure 3.

FIGURE 3: RELATIONSHIP AMONG POLICY DOCUMENTS, PRIORITY COMMITMENTS, AND PLANNING FEATURES SELECTED FOR INCLUSION IN THE ANALYSIS.



Mapping of Nature-based Action Zones in Liberia

Liberia identified four nature-based actions that were critical to include in its ELSA map: protect, manage and restore natural ecosystems, and urban greening. To determine where each of these actions can take place, the core team identified simple “rules”, or constraints that could be used with existing spatial data to map the zones where each action could occur on a map.

Based on the national definitions for each action identified in Table 1, the protection zone includes areas with ecosystems and habitats that can achieve maximum environmental, social, economic, and scientific benefits for present and future generations. The protection zone was mapped as terrestrial areas with a human footprint index less than 16, which helped identify areas with limited human pressure that are more suitable for protection. Agriculture concessions, forestry concessions and plantations in the country were excluded from the zone as they were highly modified areas that are not suitable for protection.

The management zone covers areas that allow sustainable ecosystem-based uses of forest and agricultural resources that do not harm the health of the ecosystem The management zone therefore included areas mapped as national agriculture concessions, forest concessions, community forest, plantations, and cropland to identify areas with potential needs for agriculture and forestry management.

The restoration zone includes areas where rehabilitation or replacement of soil and flora could support a return to the biological, geological, archeological, or historical features of a particular areas. In Liberia, this was mapped using the human footprint i, with a threshold of 5 to 17. This identified the middle 60% of Liberia's terrestrial land with mild and middle level of human modification, and, excluded areas that are highly modified and intensively used human settlements.

The urban greening zone includes urban areas. This zone was mapped to include the cities and built-up areas in Liberia.

The constraints used in Liberia to spatially define where each of these actions can occur is summarized in Table 1.

- The analysis: How can Systematic Conservation Planning help us to see where nature-based actions will be most effective to meet national priorities?

The ELSA analysis (Figure 1: Steps 4-7) for Liberia uses Systematic Conservation Planning (SCP) to identify where nature-based actions to protect, manage, restore, and urban greening can lead to the best outcomes across the ten policy commitments identified through stakeholder consultations (Margules & Pressey 2000). SCP is a peer-reviewed, gold-standard approach for conservation that helps identify where nature-based actions can achieve maximum impact across multiple, often competing, priorities in each study area, region of interest, or country.

The value of using SCP to run the ELSA analysis is two-fold. First, it assesses all planning features that map the ten priority commitments at once, enabling capitalization on synergies to determine where actions can most effectively achieve the greatest impact across all policy commitments.

The ELSA analysis also offers the option to create separate maps focused only on the commitments related to the three themes -- biodiversity, climate change adaptation and mitigation, and human well-being -- in order to provide customized maps to support action within specific sectors. Second, the ELSA analysis enables diverse stakeholder groups to weight the relative importance of the various planning features associated with the priority policy commitments, view tradeoffs that result from conflicting priorities, and foster dialogue around cross-sectoral collaboration and implementation.

TABLE 1. NATURE-BASED ACTIONS AND AREA-BASED TARGETS USED IN THE ELSA ANALYSIS

Action	National Definition of Action	Area-based Target	Origin of Target	Spatial Definition of Zone for Each Action	Spatial Constraints for Zone
PROTECT	Understood from the meaning of conservation that is defined as: "The sustainable management and protection of ecosystems and habitats to achieve maximum environmental, social, economic, and scientific benefits for present and future generations". (Wildlife Conservation and Protected area Management Law, page 7, 2016)	20.7% of national territory	Pro-poor agenda for prosperity and development: Increase environmentally protected areas to 30% Achieve the protection of 30% of the total forest areas (69%).	Analyse HFP distribution within protected areas, set protection threshold using the HFP that excludes the 5% most modified area of existing protected areas, exclude all agriculture concessions, forestry concessions and plantations.	• All areas where HFP<16 • Exclude all agriculture concessions, forestry concessions and plantations
MANAGEMENT	Particularly the Law includes a definition of sustainable use of protected areas that can light the analysis. Multiple Sustainable Use Reserve (Protected area with sustainable use of natural resources): Protected areas that conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. An area, set aside pursuant to Chapter 6 of this Act, to allow sustainable ecosystem-based uses of Forest Resources, including subsistence uses but within parameters which do not harm the health of the ecosystem.	15.6% of national territory	NBSAP: Target 2.3: By 2022, principles of sound rangeland and sustainable forest management, and good environmental practices in agriculture and forestry are applied in at least 50 per cent of all relevant areas.	All agriculture concessions, forestry concessions, and community forests, and mapped agriculture.	In national agriculture concession, forest concession, community forest, plantations, and global data on crops

RESTORATION	In accordance with the Section 90 of the EPA ACT of 2003, the restoration includes restoring land, including the replacement of soil, the replanting of trees and other flora and outstanding geological, archaeological or historical features of the land or the area contiguous to the land specified in the order.	10% of national territory	LDN is achieved by 2030 as compared to 2015 and an additional 10% of the national landscape has improved (net gain)	Middle 60% of HFP.	Areas where 5<HFP<17
URBAN GREENING	Active restoration of greenspace and trees. Decreases the urban heat island effect by 2-3°C, improves health and well being of urban residents, provides habitat for some biodiversity. (Default definition)	0.5% of national territory	Default setting from global target. Used when national targets are not available.	Cities and built-up areas	Liberia's cities and built-up areas

Several key terms from SCP are used in the ELSA analysis and the ELSA Webtool. Find their general definitions and their specific definitions for your country in Annex 1. Two elements of this analysis are critical to understand: weights and impacts.

- Weights: Weights enable users to set relative priorities across the planning features associated with their policy commitments. Weighing is implemented in the ELSA webtool on a scale of zero to five. For example, if Liberia assigns greater importance to the chimpanzee habitat than wetlands restoration, the maps will reflect both, but prioritize areas most important for chimpanzee habitat over those important for wetlands restoration.

- Impacts: An impact score is given to determine how each nature-based action contributes to achieving each planning feature. This impact score is determined by the ELSA science team based on the specific actions and planning features in each country. For instance, only the urban greening action can contribute to achieving policy commitments around urban resilience as it is the only action that is compatible with cities and developed spaces.

After stakeholder engagement to determine the relative weight of each planning feature, the ELSA webtool will create a map that shows where the country should take each nature-based action in order to optimize impacts across all of the planning features. To verify that the optimization has produced results that are satisfactory for the country, the webtool will also output an Excel file that documents the degree to which each planning feature can be represented by implementing the actions documented in the ELSA map, relative to what is possible under a targeted planning scenario. A score of 100% means that the planning feature has been represented as well in the ELSA map (which optimizes for all planning features) as in a more directed planning scenario that only focuses on the theme (biodiversity, climate change adaptation and mitigation, or human well-being) to which that feature belongs.

In cases where the ELSA map represents substantially less of a given feature than the more targeted scenario (typically identified as 80% or less), stakeholders can revise the weighting to ensure better outcomes for a given planning feature. The ability to change weighting for each planning feature in the ELSA webtool enables an iterative approach to developing the ELSA map, where stakeholders can revise weighting to better deliver across all planning features and measure the results using the downloaded table. The weighting can also be revised over time as the relative importance of the ten priority commitments shift in the country. For more information on iterating the analysis, please see the ELSA webtool manual.

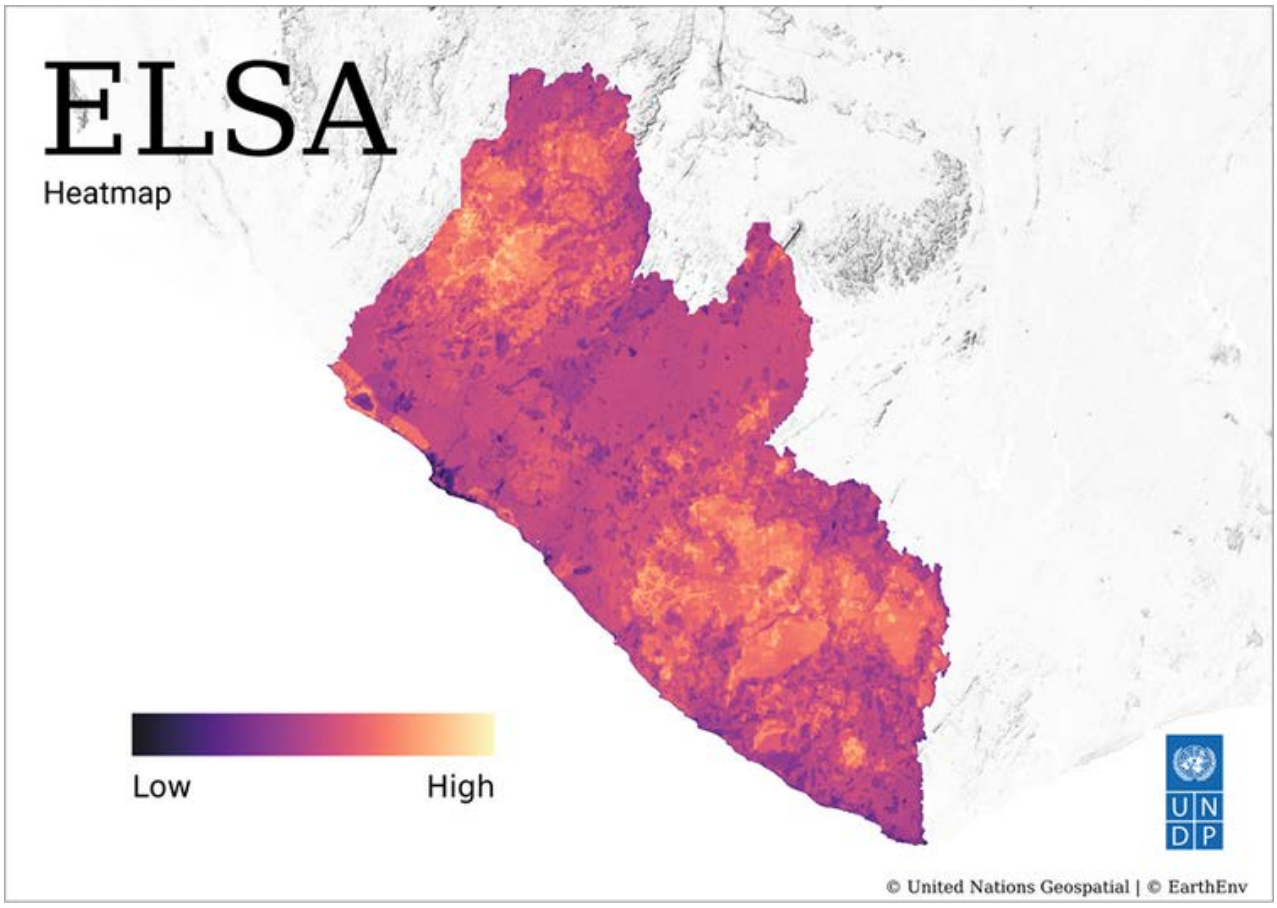
Overall, the ELSA analysis provides Liberia with an outcome-orientated map to implement nature-based solutions that will contribute to the achievement of the ten priority policy commitments and support the country to achieve adaptive sustainable management of natural ecosystems.

The ELSA Analysis & Results for Liberia

The first ELSA products for Liberia are heatmaps (Figure 4) of ecological values across the country. The heatmaps identify the distribution of ecological values that support Liberia's ten priority commitments. The heatmaps are the result of the intersection of the planning features and their respective weights. The higher the value on a range from zero to one, the more features of high weight overlap. The heatmaps thus show overall areas of importance for biodiversity, climate change, and human well-being in Liberia. The first map shows the distribution of biodiversity values, the second of values relating to climate change and the third map the values supporting human well-being. These maps show some areas of coincidence or overlap in areas of warm colors or high values, but also some differences. The fourth and final map shows the distribution of all these values combined. For more information on accessing these different heat maps, please see the ELSA webtool manual.

By looking at the heat maps before the action maps, data experts can view the combined planning feature data, and determine if the patterns are aligned with their expectations and personal knowledge of the region. However, these maps don't yet indicate the best places to take action to contribute to the achievement of the ten priority policy commitments.

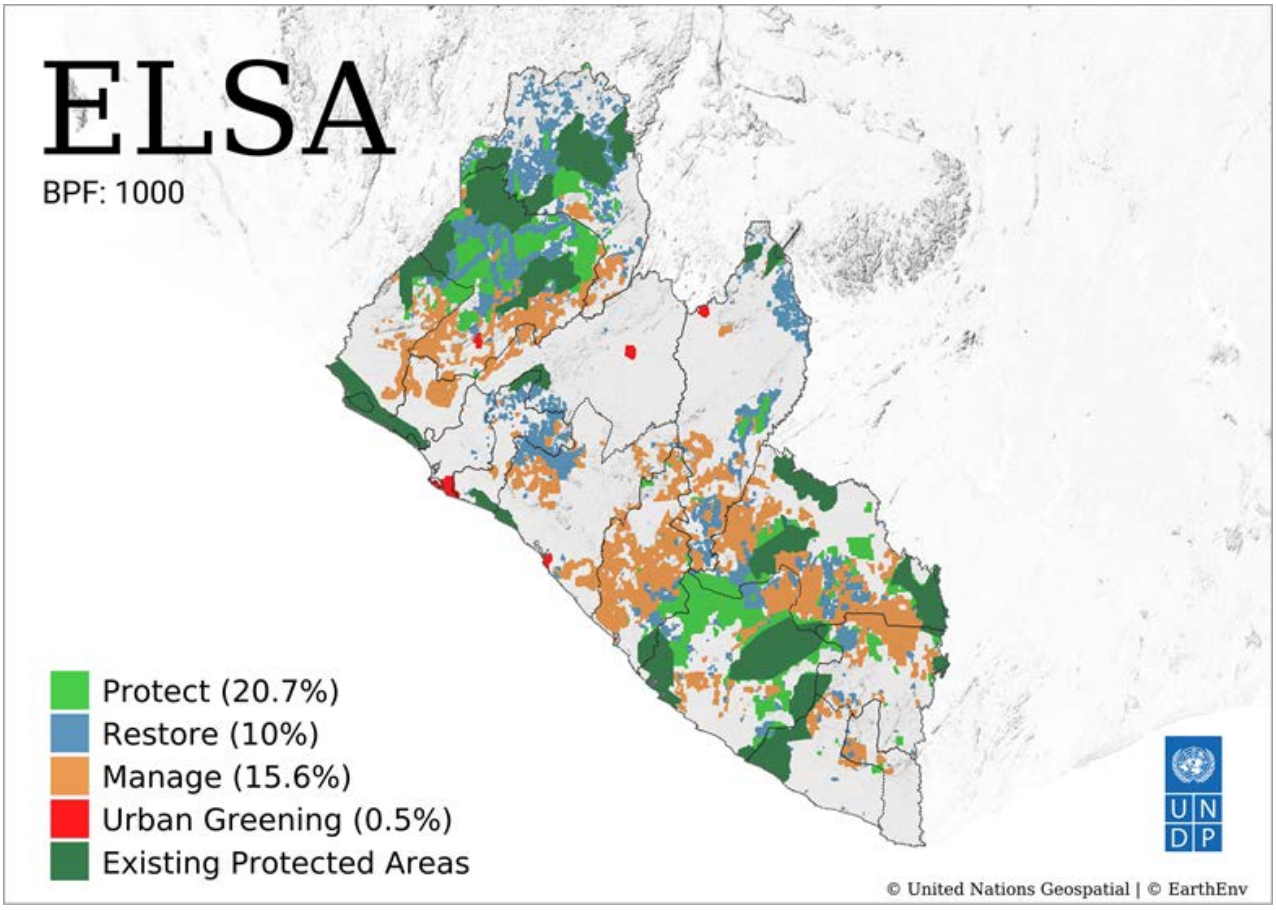
FIGURE 4: ELSA HEATMAP -- AREAS IMPORTANT FOR BIODIVERSITY, CLIMATE CHANGE, AND HUMAN WELL-BEING.

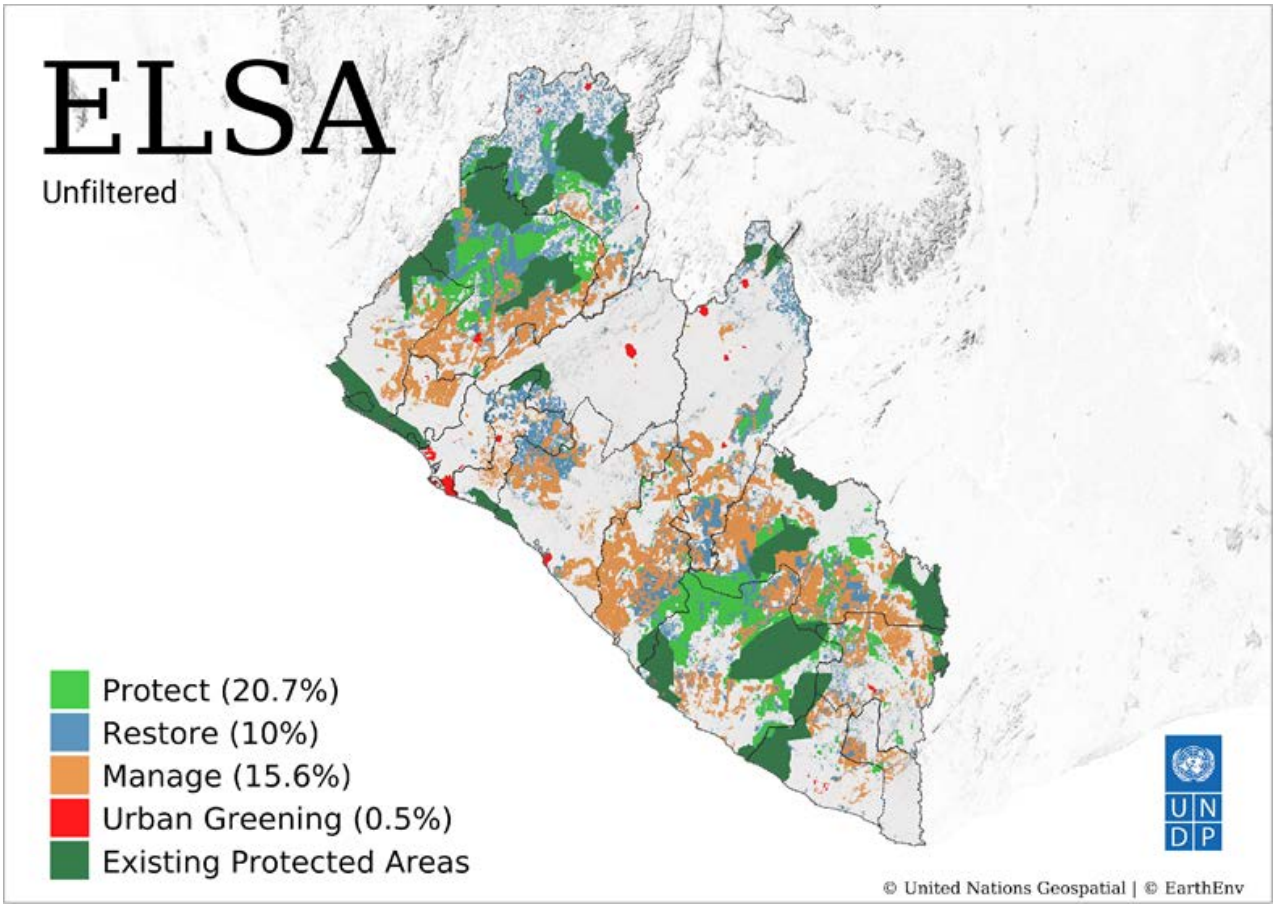


The second ELSA product for Liberia is the ELSA action map. This results from the ELSA optimization analysis. It shows areas that should be prioritized for protection, management, restoration, and urban greening in order to most efficiently deliver across the ten policy commitments associated with biodiversity, climate change adaptation and mitigation, and human well-being.

The ELSA action map, developed and validated by stakeholders in Liberia, demonstrates where actions can most effectively achieve the greatest impact across all planning features. Two versions of the map are available: a filtered version and an unfiltered version (Figure 5). The term 'filtered' refers to an ELSA map that is produced using a higher boundary penalty factor (BPF) that results in areas being selected that are both larger and more contiguous. These larger and more contiguous areas closely resemble typical protected area networks, which consider logistical and management considerations (costs) in their creation and implementation, costs which are often more efficient when implemented across a smaller number of larger areas. Further, large, more contiguous areas can often protect important landscape level connectivity and processes. The term 'unfiltered' refers to an ELSA map that captures the most optimal outputs (at the pixel level) of the ELSA analysis and shows small areas where nature-based actions would produce optimal outcomes for the ten priority commitments.

FIGURE 5: THE ELSA MAP FOR LIBERIA. (A) FILTERED ELSA MAP. (B) UNFILTERED ELSA MAP





The project 'Mapping Nature for People in Planet' worked with stakeholders in Liberia to produce a map of 'Essential Life Support Areas' that optimizes nature-based solutions for protecting, restoring, and managing nature to achieve national goals for nature, climate, and sustainable development. In the ELSA map, the areas where each nature-based action can have the biggest impact for Liberia's ten priority targets are shown in green, blue, orange, and red.

- Areas colored in blue are locations identified by the ELSA analysis as those where protection can have the biggest impact. The total area for protection is 20.7%, based on Liberia's existing goal in the Pro-poor Agenda for Prosperity and Development. Dark green areas indicate existing protected areas, and light green areas recommend areas prioritized for new protection.
- Areas colored in blue are locations where restoration can best contribute to national priorities. The total area for restoration is 10%, based on Liberia's Land Degradation Neutrality Target.
- Areas colored in orange are those prioritized for sustainable management. The total area for management is 15.6% of the national land areas (50% of relevant land for rangeland and sustainable forest management) based on NBSAP Target 2.3.

- The technology: How is the ELSA analysis run?

The ELSA analysis uses the prioritizr software library (In the R programming language) as a decision support tool to run SCP analyses (Hanson et al. 2021). The prioritizr package implements integer linear programming (ILP) techniques to provide a flexible interface for building and solving conservation planning problems (Beyer et al. 2016). It supports a broad range of objectives, constraints, and penalties that can be used to custom-tailor conservation planning problems to the specific needs of a conservation planning exercise.

There are also other decision support tools like Marxan and Zonation that can be used to run SCP analyses. The ELSA project uses prioritizr because it can solve large problems (>1 million cells) faster than other approaches, allowing real-time analysis with stakeholders, and it guarantees that the optimal solution can be found.

Remember, regardless which decision support tool you use, they are designed to help you make decisions—they can't make decisions for you.

Implementation of the ELSA Map

Contribution of ELSA to policy development in areas of strategic importance

The ELSA process provides an opportunity to generate integrated landscape analyses to support policy development for environmental, agricultural and land management challenges.

● Supporting development and implementation of the Kunming-Montreal Global Biodiversity Framework of the Convention on Biological Diversity

The ELSA approach can also guide the development, implementation, and monitoring of progress for the Kunming-Montreal Global Biodiversity Framework in Liberia. In particular, ELSA can support national processes around the following targets of the draft framework;

- Target 1 on land and sea areas under integrated spatial planning;
- Target 2 on restoring at least 30 percent of areas of degraded ecosystems;
- Target 3 on protecting and conserving at least 30 percent of the planet;
- Target 8 on increasing contributions to climate change mitigation, adaptation, and disaster risk reduction from nature-based solutions;
- Target 10 on supporting the productivity, sustainability and resilience of biodiversity in agricultural and other managed ecosystems;
- Target 11 on ensuring that nature-based solutions contribute to regulation of air, water, and climate, soil health, pollination and reduction of disease risk for human well-being; and
- Target 12 on increasing the area and benefits from green and blue spaces in urban areas.

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Annex 1: Key Terms Used in the ELSA Process

TERM	DEFINITION	APPLICATION IN LIBERIA
Boundary penalty factor (BPF)	Penalty given to solutions based on the total exterior boundary or edge of zones. By penalizing high edge length solutions, this BPF can be used to promote spatial cohesion or clumping in ELSA areas.	A boundary penalty factor of 500 was applied to produce the second ELSA map for Liberia. This score was selected to create a scientifically rigorous but actionable map that promotes protection, management, restoration, and urban greening over contiguous areas.
Area-based target (budget)	The maximum land area (expressed as % of total country land area) that can be allocated to a 'zone'.	Protect: 20.7% Manage: 15.6% Restore: 10% Urban greening: 0.5%
Planning feature	An element of biodiversity or ecosystem service selected as a focus for conservation planning or action. This can include ecological classifications, habitat types, species, physical features, processes or any element that can be measured in a planning unit. In the ELSA process, each priority commitment for a country may correspond to one or multiple planning features depending on its complexity.	The ELSA webtool for Liberia includes 26 features that map the ten priority policy commitments (Figure 3).
Decision support software	A computer-based application that uses information on possible actions and constraints on these actions in order to aid the process of decision-making in pursuit of a stated objective.	For the ELSA project in Liberia, prioritizr is used as the decision support software.
Geographic Information System (GIS)	A computer-based system consisting of hardware and software required for the capture, storage, management, analysis and presentation of geographic (spatial) data.	The ELSA webtool uses GIS software to present spatial data to users. No GIS expertise is required to use it.
Constraint	A rule that must be met during the optimization as it creates a network of zones. The primary constraints are that the budget (land area dedicated to each ELSA action) must not be exceeded, and that each zone can only occur within specified planning units (e.g., protection zone may only be possible in planning units that are not agricultural or urban land covers)	Please see Table 1 for more details.

Impacts	The degree to which a specific zone contributes to the status of a specific planning feature. Values typically range from '0' (no contribution) to '1.5' (an increase of 50% from current condition).	The impact score for the effect of protection, restoration, and management on each of the planning features for Liberia was determined through a rigorous scientific process.
Maximum coverage problem	The objective of the maximal coverage problem is to maximize protection of features subject to the constraint that the resources expended do not exceed a fixed cost.	The ELSA process in Liberia uses a maximum coverage problem formulation.
Minimum set problem	The objective of the minimum-set problem is to minimize resources expended, subject to the constraint that all features meet their conservation target.	Not applicable for the ELSA process.
Planning Units	Planning units are the building blocks of a reserve system. A study area is divided into planning units that are smaller geographic parcels of regular or irregular shapes. Examples include squares, hexagons, cadastral parcels and hydrological units.	Coordinate Reference System: Custom Mollweide projection Resolution or pixel size: 350m x 350m
Representation	In Systematic Conservation Planning, a representative system captures a full range of planning features (species, ecosystems, and ecosystem services) occurring within the planning region, not just iconic species.	In the ELSA Liberia analysis, representation is used to measure how well the ELSA areas capture or represent planning features relative to a more directed planning approach focused only on biodiversity, climate change, or human well-being.
Systematic conservation planning (SCP)	Formal method for identifying potential areas for conservation management that will most efficiently achieve a specific set of objectives, commonly some minimum representation of biodiversity. The process involves a clear and structured approach to priority setting, and is now the standard for both terrestrial and marine conservation. The effectiveness of systematic conservation planning stems from its ability to make the best use of limited fiscal resources towards achieving conservation goals and do so in a manner that is defensible, accountable, and transparently recognises the requirements of different resource users.	SCP is the science that enables the identification of ELSAs in Liberia.

User interface	The means by which people interact with a particular software application. A Graphical User Interface (GUI) presents information in a user-friendly way using graphics, menus and icons. The ELSA Webtool is a GUI that provides stakeholders with the ability to directly run the ELSA analysis themselves.	The ELSA Webtool is a GUI that provides stakeholders with the ability to run the prioritizr ELSA analysis themselves.
Weights	Weights enable users to set relative priorities within their priority policy outcomes. Values typically range for '0' (no importance) to '5' (extremely high importance)	The default weights for the Liberia ELSA analysis were collaboratively developed through two stakeholder engagement sessions. Stakeholders can modify these weights through the ELSA webtool based on changed priorities.
Zones/Actions	A land use zone, equivalent to a nature-based action, that serves to improve specific planning features. Zones are determined by constraints that define where an action absolutely can or cannot occur. For example, these hard constraints limit protection to intact areas (e.g., low human footprint values) and protection/restoration to areas that are moderately impacted by human activity, but not fully human dominated (e.g., low to mid human footprint values).	In Liberia, the ELSA analysis zoning maps three different actions: protect, manage, restore, and urban greening Data used for zoning constraints including human footprint, agriculture concessions, forestry concessions, and community forests, mapped agriculture, and urban areas.

Annex 2: Data layers used in ELSA Liberia

GROUPS	LABEL-THEME	LABEL-NAME	DATA SOURCE (INSTITUTE)	REFERENCE
Features	Biodiversity	Underrepresented ecosystems	This layer is a composite incorporating the natual ecosystems from CI-NASA_Ecosystem_Base_Map_2021 (built-up, barrenland, plantations excluded) and national protected areas. If the coverage of protected areas within a certain ecosystem is under 16.66% (protect target), this ecosystem is considered to be underrepresented. The value assigned to a planning units is the unprotected percentage of areas within overlapping ecosystems.	The Conservation International-NASA Partnership
		Threatened ecosystems	This layer calculates ecosystem threat status as the proportion of an ecosystem with an intactness value less than the median intactness value among all planning units within the country.	The Conservation International-NASA Partnership, 2021 Beyer HL, Venter O, Grantham HS, Watson JEM. 2020. Substantial losses in ecoregion intactness highlight urgency of globally coordinated action. Conservation Letters 13:e12692.
		Accessible mangroves	Mangrove belt along the costline of Liberia. Required for the theme of "coastal management" which targets the restoration of at least 30% of degraded wetlands (Target 7)	Neugarten, Rachel & Alam, Mahbubul & Acero, Natalia & Honzák, Miroslav & Juhn, Daniel & Koenig, Kellee & Larsen, Trond & Moull, Kevin & Rodriguez, Ana & Wright, Timothy & Walsh, Liam & Donovan, Jessica & Mulbah, Peter & Valenza, Jim & Reuter, Kim & Portela, Rosimeiry & Noviello, Tim & Wade, Shelly & Hole, David & Junker, Jessica. (2017). Natural Capital Mapping and Accounting in Liberia: Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. 10.13140/RG.2.2.33270.70725.

		Ramsar sites	Wetlands of international importance in Liberia. Boundaries of wetlands are important to ensure the restoration of at least 30% of degraded wetlands (target 7)	Environmental Protection Agency (EPA)
		Key Biodiversity Areas	Key Biodiversity Areas are sites that contribute significantly to the global persistence of biodiversity in terrestrial, freshwater, and marine ecosystems. Sites qualify as global KBAs if they meet one or more of 11 globally agreed upon criteria, including: threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability. Data updated to March 2022.	BirdLife International. 2022. World Database of Key Biodiversity Areas. Managed by BirdLife International on behalf of the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, American Bird Conservancy, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:Wild, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. March 2022 Version. Available at http://www.keybiodiversityareas.org
		Conservation priority areas	MARXAN modeled conservation priorities showing 30% best patches for the best performing conservation scenario, model collected nationwide data on chimpanzee abundance, large mammal and tree taxonomic diversity, and human threats.	Junker, J., Boesch, C., Freeman, T., Mundry, R., Stephens, C., & Kühl, H. S. (2015). Integrating wildlife conservation with conflicting economic land-use goals in a West African biodiversity hotspot. Basic and Applied Ecology, 16(8), 690-702.
		Mean area of forest patches	Forest fragmentation - mean size of mature forest patches in a 3x3 km grid derived from the NASA 2018 land cover data	De Sousa, C. et al. (2023) Two Decades of Forest Fragmentation in Liberia (in prperation).
		Degraded forests	Layer represents degraded forest with low forest integrity. Reversed Forest Structural Integrity Index (FSII) value in moderately and severely degraded forest extracted from CI-NASA_Ecosystem_Base_Map_2021, high values are areas with low forest integrity.	The Conservation International-NASA Partnership Hansen A et al. 2019. Global humid tropics forest structural condition and forest structural integrity maps. Scientific Data 6:1–12.

		Degraded wetlands	Layer represents degraded forested wetland with low forest integrity. Reversed Forest Structural Integrity Index (FSII) value in wetlands where human footprint value >3. Wetland areas include water body, mangrove and marsh from landcover 2021 and ramsar.	The Conservation International-NASA Partnership Hansen A et al. 2019. Global humid tropics forest structural condition and forest structural integrity maps. Scientific Data 6:1–12. Williams BA et al. 2020. Change in Terrestrial Human Footprint Drives Continued Loss of Intact Ecosystems. One Earth 3:371–382. Elsevier.
		Modeled tree taxonomic diversity	Modeled tree taxonomic diversity - tree species richness	Junker, J., Boesch, C., Freeman, T., Mundry, R., Stephens, C., & Kühl, H. S. (2015). Integrating wildlife conservation with conflicting economic land-use goals in a West African biodiversity hotspot. Basic and Applied Ecology, 16(8), 690-702.
		Species richness	SPARC data - Species richness including birds, mammals, reptiles, amphibians and plants. Species models are 2.5 arc-minute resolution	CI. Spatial Planning for Area Conservation in Response to Climate Change
		Chimpanzee habitat suitability	MaxEnt habitat suitability of western chimpanzee subspecies (P. troglodytes verus) in LBR, Critically Endangered.	Frazier A.E., Honzák M., Hudson C., Perlin R., Tohtsonie A., Gaddis K.D., de Sousa C., Larsen T.H., Junker J., Nyandwi S., Trgovac A.B (2021) Connectivity and conservation of Western Chimpanzee (Pan troglodytes verus) habitat in Liberia. Diversity and Distributions 27:1235–1250
		Chimpanzee connectivity	Circuitscape results for connectivity amongst the north and south occurrences of the western chimpanzee	Frazier A.E., Honzák M., Hudson C., Perlin R., Tohtsonie A., Gaddis K.D., de Sousa C., Larsen T.H., Junker J., Nyandwi S., Trgovac A.B (2021) Connectivity and conservation of Western Chimpanzee (Pan troglodytes verus) habitat in Liberia. Diversity and Distributions 27:1235–1250
	Climate Change Adaptation & Mitigation	High carbon in concessions	Above ground biomass in concessions areas (plantations, forest concessions, agriculture concessions, and community forests), high value represent high carbon density	Forestry Development Authority, 2021 De Sousa, C., Fatoyinbo, L., Neigh, C., Boucka, F., Angoue, V., & Larsen, T. (2020). Cloud-computing and machine learning in support of country-level land cover and ecosystem extent mapping in Liberia and. PLOS ONE 1–24.

		Above ground biomass carbon density-NCER	Africa-wide above ground biomass carbon density (MgC/ha) produced at 100 m resolution for 2017	Rodriguez Veiga, Pedro; Balzter, Heiko (2021): Africa Aboveground Biomass map for 2017. University of Leicester. Dataset.
		Sediment regulation	Important areas for Sediment Regulation (potential service). It shows the average amount of sediment regulated (sediment erosion and retention) annually by a hectare of land within each level 9 watershed. Areas of higher values (darker blue) provide more potential sediment regulation services. In other words, these areas are important for sediment regulation, but those benefits are not necessarily used ("realized") by anyone downstream. Vegetation cover should be maintained or restored to reduce sediment loads in rivers / erosion	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Soil organic carbon	2020 global gridded soil organic carbon (0-30 cm)	Poggio, L., De Sousa, L. M., Batjes, N. H., Heuvelink, G., Kempen, B., Ribeiro, E., & Rossiter, D. (2021). SoilGrids 2.0: producing soil information for the globe with quantified spatial uncertainty. Soil, 7(1), 217-240.
		Mangrove aboveground biomass	This dataset estimates the aboveground biomass (AGB) of mangrove-forested wetlands based on remotely sensed and in situ field measurement data for the nominal year 2000 were derived across a 30-meter resolution global mangrove ecotype extent map using remotely-sensed canopy height measurements and region-specific allometric models.	Simard, M., T. Fatoyinbo, C. Smetanka, V.H. Rivera-monroy, E. Castaneda, N. Thomas, and T. Van der stocken. 2019. Global Mangrove Distribution, Aboveground Biomass, and Canopy Height. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1665

	Human Well-being	Essential natural capital for food security	Natural ecosystems that are accessible to people, layer include Forest, Mangrove & swamps, Surface water bodies, Grassland, and Shrub.	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Coastal protection	Coastal protection provided by mangroves ("habitat role") provided by InVEST model. Higher value areas indicate where mangroves provide more protection, relatively high in Bassa and Rivercess counties. These mangroves should be conserved or restored to ensure they continue providing this valuable benefit to people along the coast.	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Essential natural capital	All combined essential natural capital, including Essential natural capital for biodiversity, Essential natural capital for forest carbon, Essential natural capital for coastal protection, Essential natural capital for freshwater ecosystem services	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Important areas for water quantity	Important areas for the provision of potential freshwater services related to water quantity (capture of atmospheric water). The map can be used to target conservation or restoration investments to maintain and/or enhance the provision of water with a stable and predictable flow downstream.	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International

		Important areas for flow regulation	Important areas for flow regulation services - a steady predictable supply of water. The map can be used to target conservation or restoration investments to maintain and/or enhance the provision of water with a stable and predictable flow downstream.	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Potential freshwater provision	A summary map showing areas important for provision of potential freshwater services (quantity, quality, and flow regulation)	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International
		Flood regulation	Layer shows areas of natural capital (forest and herbaceous vegetation) that regulate water flows, weighted by the number of people downstream living in areas of increased flood risk. Areas of higher value (darker blue areas) have natural vegetation that regulates water flows, and provide flood regulation services for a greater number of people downstream. This map indicates that conserving vegetation cover in the watershed surrounding and immediately upstream of Monrovia is the most important area to reduce the risk of flooding for a large number of vulnerable people downstream.	Neugarten, R., Alam, M., Martinez, N. A., Honzák, M., Juhn, D., Larsen, T., Moull, K., Rodriguez, A. M., Wright, T., Walsh, L., Donovan, J., Mulbah, P., Valenza, J., Reuter, K., Portela, R., Wade, S., Hole, D., Peralvo, M., Silver, J., & Junker, J. (2017). Natural Capital Mapping and Accounting in Liberia - Understanding the contribution of biodiversity and ecosystem services to Liberia's sustainable development. Conservation International

		Urban Greening Opportunities	The urban greening opportunities layer indicates urban areas with low NDVI and exposure to extreme heat. Urban areas are cities in Liberia, higher weights on the 5 cities lised as priorities in the policy target. The value in each urban planning unit is calculated as the scaled (0-1) inverse average value of NDVI plus the urban heat index. MODIS-NDVI updated to 2023.	Liberia Institute of Statistics and Geo-information Services (LISGIS) Didan, Kamel. 2015. MOD13Q1 MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006. NASA EOSDIS Land Processes DAAC. Available from https://lpdaac.usgs.gov/products/mod13q1v006/ (accessed August 26, 2022). Tuholske C, Caylor K, Funk C, Verdin A, Sweeney S, Grace K, Peterson P, Evans T. 2021. Global urban population exposure to extreme heat. Proceedings of the National Academy of Sciences 118:e2024792118. Proceedings of the National Academy of Sciences.
Lock-in		Protected Areas	National protected areas 2021	Government of Liberia
		Forest restoration project	Forest restoration project area where trees have been planted to restore degraded forest, in a collaboration involving farmers, nongovernmental organizations, construction workers, community leaders, and local officials are combining climate-resilient farming methods and re-afforestation in Foya, Lofa County. It is important for the 'restoration theme' which seeks to strengthen and/or implement reforestation and afforestation activities as a National Policy and Response Strategy to Climate Change (Target 6)	Forestry Development Authority
Zones-restrictions		Protect	Analyse HFP distribution within protected areas, set protect threshold using the HFP that excludes the 5% most modified area of existing protected areas, exclude all agriculture concessions, forestry consessions and plantations	

		Manage	All agriculture concessions, forestry concessions, and community forests, and mapped agriculture	
		Restore	Middle 60% of HFP	
		Urban-greening	Liberia cities and built-up areas from NASA landcover	

EPA

Sida

UNDP