National Assessment of

BIODIVERSITY AND ECOSYSTEM SERVICES of Colombia

SUMMARY FOR POLICYMAKERS

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Document written following the methodology of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

Bogotá, D. C., Colombia.
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Final comments
Some key messages about the Covid-19 pandemic were included without an established confidence level, as they were developed from secondary information and specific consultations.

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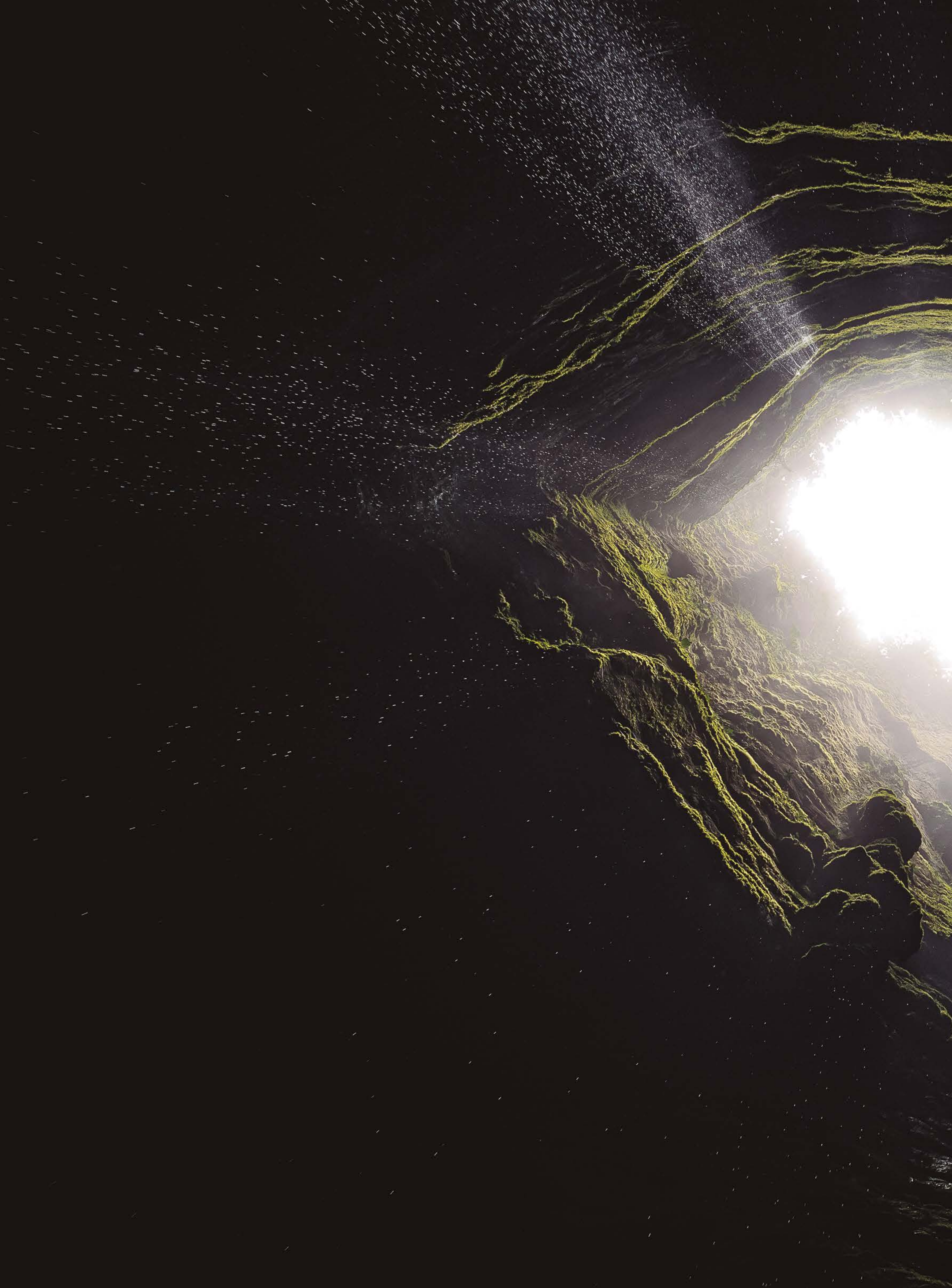
SUMMARY FOR POLICYMAKERS



In memoriam

Javier Maldonado

Much of the knowledge summarised in this document draws from the seven chapters of the National Assessment of Biodiversity and Ecosystem Services. Javier Maldonado, one of the leading authors of the assessment and coordinator of Chapter 2, devoted his entire professional life to studying the ichthyofauna of our country. Because of his contribution, we know about new species of fish that inhabit the rivers of the Amazon, the Orinoco, and the Andean and Pacific regions. Through his perseverance and generosity in sharing knowledge, he promoted the building of a database on fish in the Amazon basin. For this end, he exchanged ideas, data, legends, and biological information with fishermen from the Magdalena and their children, and from many other rivers; and contributed to the training of new researchers, biologists, and ecologists who were as passionate about life as he was. To you, Javier, we dedicate this publication that brings together the knowledge of many lives, including your own, though it was very short. Always in our hearts. Rest in peace.

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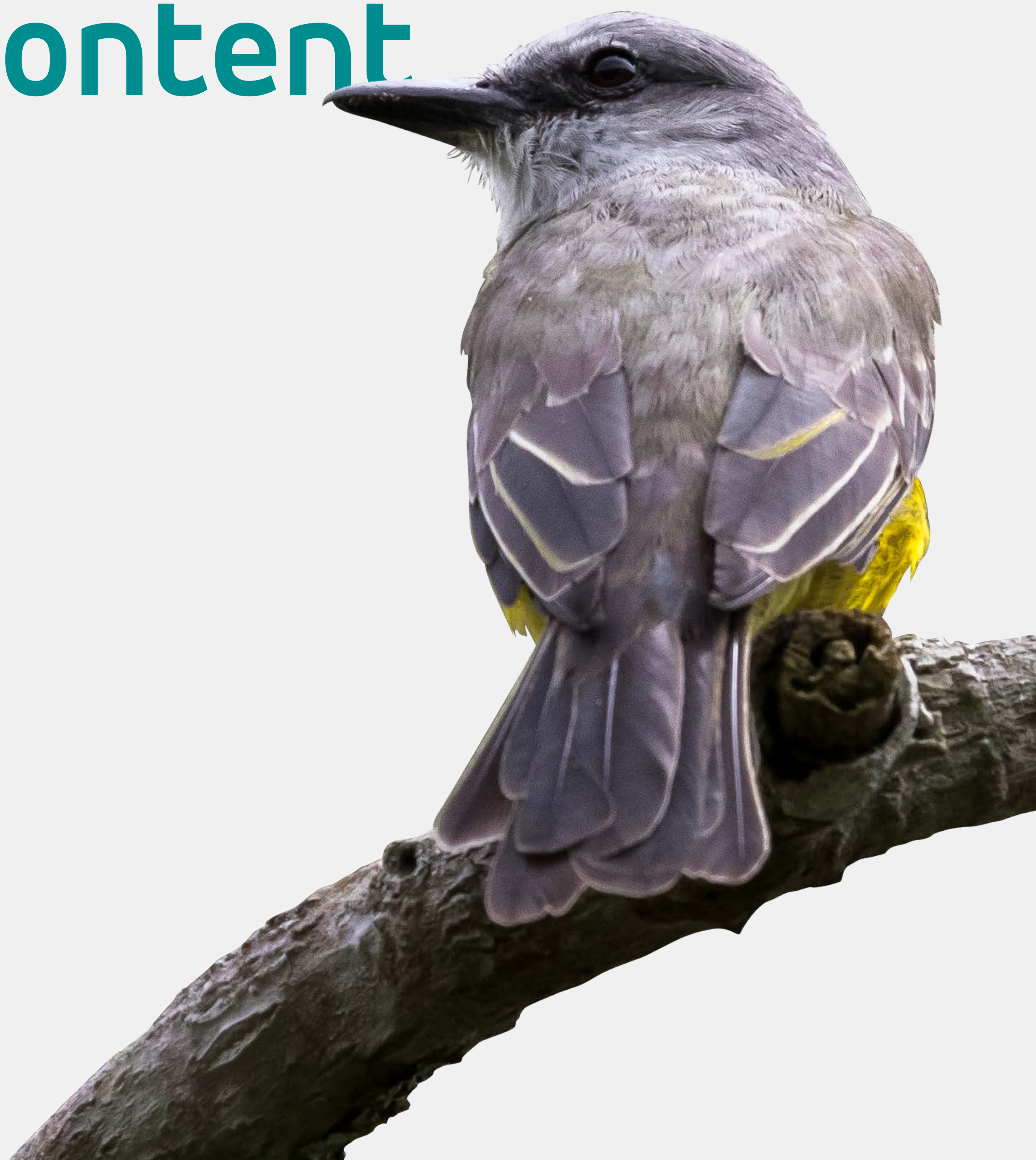
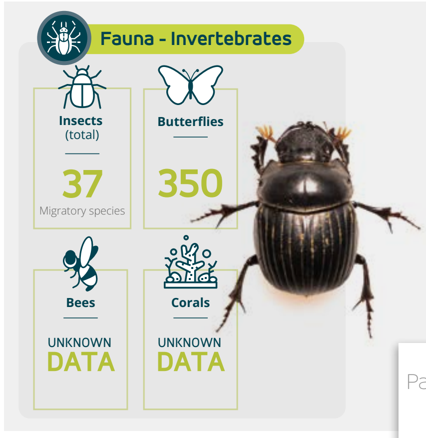



Fauna - Invertebrates
Insects
(total)
37
Migratory species
Butterflies
350
Bees
UNKNOWN
DATA
Corals
UNKNOWN
DATA

1

2

3

4

1. Species and genetic diversity

Colombia compared with the rest of the world

HOY MANY RECORDED SPECIES ARE THERE IN COLOMBIA?

63303

BIODIVERSITY IN THE WORLD

Top 10 most biodiverse countries

1st PLACE Birds, orchids, and butterflies

2nd PLACE Plants, orchids, and butterflies

3rd PLACE Palm trees, and reptiles

6th PLACE Mammals

HOW MANY ENDANGERED SPECIES ARE THERE IN COLOMBIA?	1302
HOW MANY SPECIES ARE BEING TRADED IN COLOMBIA?	3524
HOW MANY SPECIES ARE INTRODUCED, INVASIVE OR TRANSLOCATED IN COLOMBIA?	509

Number of recorded species in Colombia

Fauna - Vertebrates

Mammals
520

Marine mammals
16
(**21** are migratory species)

Birds

Andean and Pacific forests

Open, Dry, Insular Ecosystems, Continental Aquatic Ecosystems, Marine Ecosystems, Highlands of Darién and Sierra Nevada de Santa Marta, and Humid Forests in the Central, Northern, and Eastern regions of the country.

1999 (**137** are included in some kind of risk category)

Amphibians
849
(**55** are included in some kind of risk category)

Reptiles
743
(**44** are included in some kind of risk category)

Reptiles - Sea turtles
5
(All of them are migratory species and are included in some kind of risk category)

Fish - Freshwater (national level)
1439
(**110** are migratory species)

Sea fish
2574
(**64** are migratory species)

Fauna - Invertebrates

Insects (total)	Butterflies	Bees	Corals
11764	4059	333	185

Flora

Angiosperms (flowering plants)	Orchids	Magnolias and related species	Bromeliads, labiates, and passionflowers
25787	3179	127	1054

Palm trees	Espeletias (also known as frailejones)
311	93

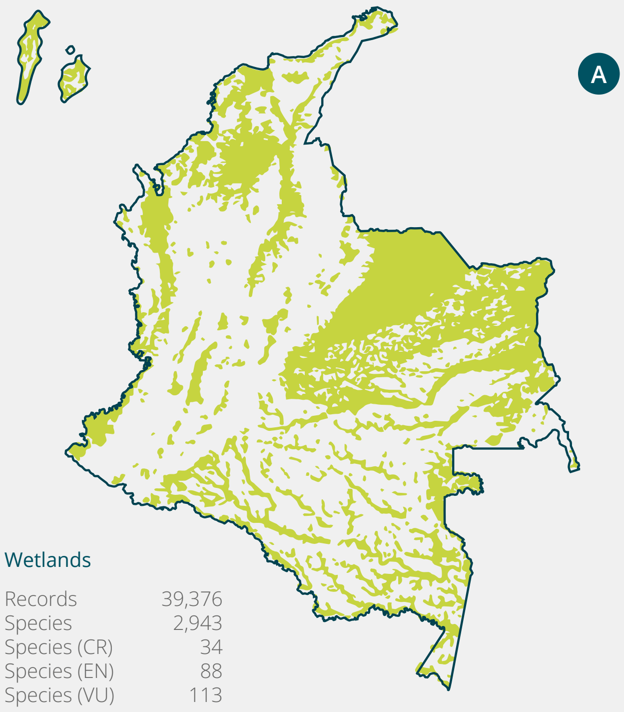
Mangroves	Timber forest products
7	441

(Cárdenas and Salinas 2007)

Continued on next page

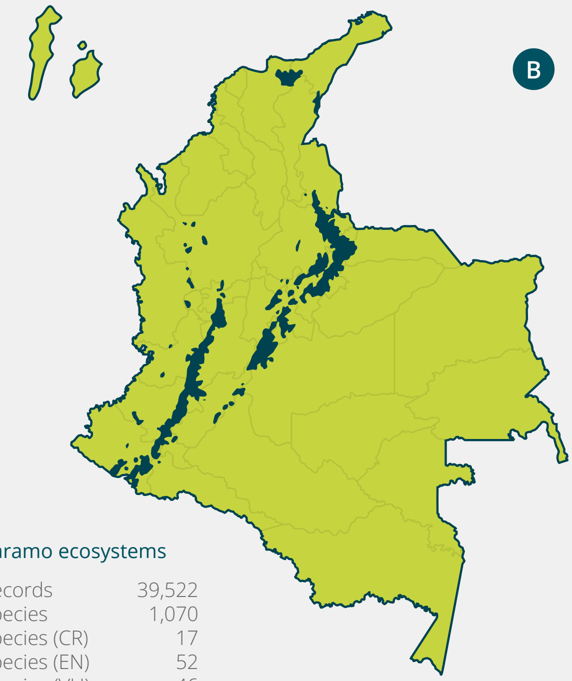
1. Species and genetic diversity

Endemism in Colombia



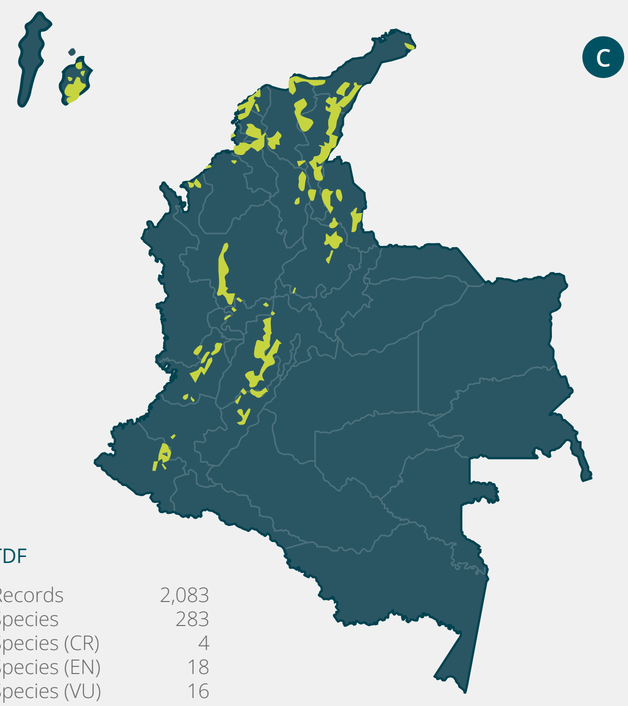
Wetlands

Records	39,376
Species	2,943
Species (CR)	34
Species (EN)	88
Species (VU)	113



Paramo ecosystems

Records	39,522
Species	1,070
Species (CR)	17
Species (EN)	52
Species (VU)	46



TDF

Records	2,083
Species	283
Species (CR)	4
Species (EN)	18
Species (VU)	16

SOME ENDEMIC SPECIES

Espeletia paipana
(Eastern Cordillera)
Aragoa Genus

Bolborhynchus ferrugineifrons
(Paramo parrot, Central Cordillera)

Chlorochrysa nitidissima
(Pre-montane forest tanager, Central and Western Cordillera)

Chlorostilbon olivaresi
(Hummingbird endemic to the Colombian Amazon)

Doliornis remseni
(Cotinga, endemic to the paramo of Putumayo - Nariño)

Number of endemic species in strategic ecosystems of Colombia. (A) Wetlands. (B) Paramo. (C) Dry tropical forest - DTF. Conservation status: Critically Endangered (CR); Endangered (EN); Vulnerable (VU); information considered up to December 2018.

Given the expected synergistic effects of climate change and habitat loss, endemic species and those dependent on natural habitats in Colombian territory will tend to reduce their populations.

Fauna - Vertebrates

Mammals
45

Amphibians
375

Fish - Freshwater (national level)
392

Birds

Andean and Pacific forests 87

Open, Dry, Insular Ecosystems, Continental Aquatic Ecosystems, Marine Ecosystems, Highlands of Darién and Sierra Nevada de Santa Marta, and Humid Forests in the Central, Northern, and Eastern regions of the country.

56 (**53** are included in some kind of risk category)

Fauna - Invertebrates

Insects (total)
37
Migratory species

Butterflies
350

Bees
UNKNOWN DATA

Corals
UNKNOWN DATA

Flora

Angiosperms (flowering plants)
UNKNOWN DATA

Orchids
UNKNOWN DATA

Magnolias and related species
UNKNOWN DATA

Bromeliads, labiates, and passionflowers
UNKNOWN DATA

Palm trees
47

Continued on next page

1. Species and genetic diversity

Risk categories

Fauna - Vertebrates

Mammals

Number of assessed species (Red Books) 75

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
24	8	6	8.1

Marine mammals

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
2	5	0	43.8

Birds

Number of assessed species (Red Books) 118

Andean and Pacific forests

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
24 (12 endemic ones)	8 (11 endemic ones)	6 (4 endemic ones) + 1 CR - PE (*)	7

Birds

Number of assessed species (Red Books) 114

Open, Dry, Insular Ecosystems, Continental Aquatic Ecosystems, Marine Ecosystems, Highlands of Darién and Sierra Nevada de Santa Marta, and Humid Forests in the Central, Northern, and Eastern regions of the country.

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
31 (11 endemic ones)	30 (12 endemic ones)	9 (3 endemic ones) + 2 CR - PE (*)	7

Amphibians

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
15	26	14	6.5

Reptiles

Number of assessed species (Red Books) 510

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
17	16	11	5.9

Reptiles - Sea turtles

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
1	1	3	100

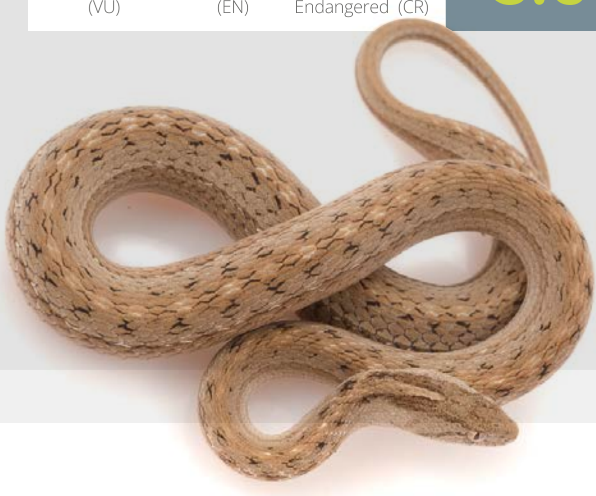
Fish - Freshwater (national level)

Number of assessed species (Red Books) 81

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
47	3	2	3.6

Sea fish

Risk category			Endangered species out of the total recorded
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)	
7	2	1	0.39



Fauna - Invertebrates

Insects (total)

Risk category

16	15	5
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **0.3**

Butterflies

Risk category

5	6	1
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **0.3**

Bees

Risk category

3	4	4
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **3.3**

Corals

Risk category

4	1	1
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **3.2**

Flora

Angiosperms

flowering plants

Number of assessed species (Red Books) **1853**

Risk category

337	255	104
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **2.7**

Bromeliads, labiates, and passionflowers

Number of assessed species (Red Books) **849**

Risk category

114	94	47
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **24.2**

Orchids

Risk category

136	64	6
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **6.5**

Magnolias and related species

Risk category

10	20	15
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **35.4**

Palm trees

Risk category

24	22	7
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **17.0**

Espeletias

(also known as frailejones)

Risk category

13	17	7
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **39.8**

Timber forest products

Risk category

10	16	8
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **68** (50 species assessed by Cárdenas and Salinas 2007)

Mangroves

Risk category

0	1	0
Vulnerable (VU)	Endangered (EN)	Critically Endangered (CR)

Endangered species out of the total recorded **14.3**

(*) CR – PE Critical Risk – Possibly Extinct

Continued on next page

1. Species and genetic diversity

Species we use for...

Most threatened species, according to corporation reports

Common Name: **Cedar**
Species: *Cedrela adorata*
Family: Meliaceae

Common Name: **Cumaru**
Species: *Aniba perutilis*
Family: Lauraceae

Common Name: **Carreto**
Species: *Aspidosperma polyneuron*
Family: Apocynaceae

Common Name: **Abarco**
Species: *Cariniana pyriformis*
Family: Lecythidaceae

Common Name: **Chaquiro**
Species: *Retrophyllum rospigliossi*
Family: Podocarpaceae

Common Name: **Colombian Pine**
Species: *Podocarpus oleifolius*
Family: Podocarpaceae

Common Name: **Oak**
Species: *Quercus bumboldtii*
Family: Fagaceae

Common Name: **Walnut**
Species: *Juglans neotropica*
Family: Juglandaceae

Common Name: **Mahogany**
Species: *Swietenia macrophylla*
Family: Meliaceae

Common Name: **Caracoli**
Species: *Anacardium excelsum*
Family: Anacardiaceae

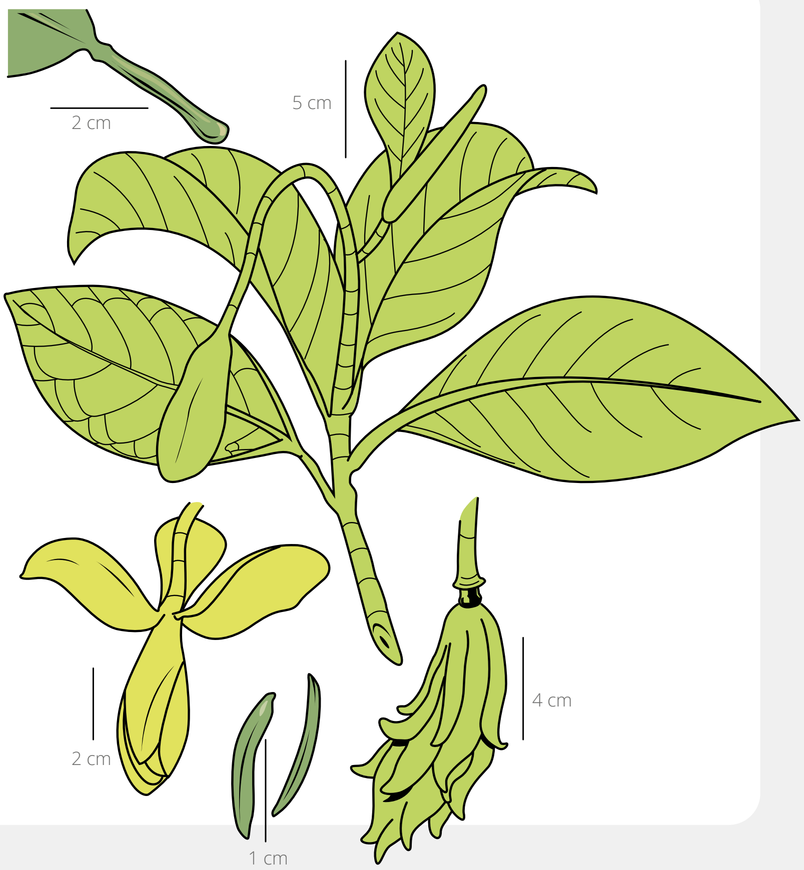
Timber forest species (Source: Cárdenas & Salinas, 2007)

Almanegra de **Ventanas**

Magnolia polyhypsophylla
(Lozano) Govaerts

Magnoliaceae family

Global category *Critically Endangered*
[CR B 1ab (iii), D1].



(Source: Cárdenas & Salinas, 2007)

On genetic diversity

The following comparison illustrates this statement. There is a reference information system called *Barcoding of Life Data system (BOLD)* that compiles DNA barcode data that identify species.

By the end of **2019** there were **recorded in this system** **6 692 933** Species with **barcode sequence**

According to **BOLD** which provides numbers on the current state of knowledge of biological diversity in a country or region based on molecules.

COLOMBIA only has **8018** *barcode* sequences

mainly from

Plants **240** species

Animals **1423** species

It is a priority to promote and consolidate genetic information on diversity within the country. To achieve this, generating clear policies and fostering synergy among national authorities, academia, and businesses are important steps to ensure that knowledge and the use of genetic heritage become the foundation of the country's green economy, through fair and equitable access to genetic resources (Well established).

2. Ecosystems and bioculture

Terrestrial, marine and other aquatic ecosystems

Paramo ecosystems

37 paramo complexes in Colombia, 4700 plant species, 17% of the country's plants. 15.4% are transformed, and 7% are found in protected areas; 55% are unprotected.

Extension in Colombia

2,906,000 ha that constitute 50% of global paramo ecosystems (Sarmiento et al., 2013)

Main ecosystem services

- **Provisioning services**
  Water security
- **Regulatory services**
  Water regulation and purification: 70% of the Colombian population, including 17 cities, depend on paramos and andean forests
- **Cultural services**
  31 indigenous reserves from 16 etnias, including sacred sites
- **Support services**
  Water cycle
  Habitat provision

Andean forests

These are present in mountain ecosystems at 1000 and 3200 masl. 18% of the national continental territory. High species richness and endemism. 1,657 plant species, 479 bird species, and 75 mammal species. 63% transformed; in the SINAP (including 16 from the SPNN), 14.7% of the total area is Andean forests, 27.4% transformed.

Extension in Colombia

Potential distribution area: 9,726,000 ha (Moreno et al. 2013).

Main ecosystem services

- **Regulatory services**

  Water regulation and purification: 70% of the Colombian population, including 20 cities, depend on paramos andean forests

  Cloud forest ecosystems store up to 15 times more water than other areas affected by human action (Ramírez, van de Ploeg et al. 2017).

  There is 1.79% of surface overflow, in montane forest there is 0.69%, and in secondary forest there is 0.39%; this means that native forests with high precipitation have low surface overflow values. In contrast, productive areas in Antioquia, with grassland and crop cover, experience 20.8% and 14.8% loss due to surface overflows, respectively (Ortega Molina 2014; Cerrón, del Castillo et al. 2019).

  Crop pollination by insects: ahuyama [pumpkin], granadilla, coffee, and guava fruit.

  Coffee: insect pollination increases production by 10%. The absence of pollinators translates into a loss of approximately 5.4% of net income (Bravo-Monroy et al. 2015)

  Cholupa: insect pollination increases production by 27%. This represents around COP5 million per hectare (Rodríguez et al., 2015).

  Most carbon is stored in forests, along with the Amazon region. Mainly in the Amazon foothills of the Eastern Cordillera and the Pacific foothills of the Western Cordillera.
- **Support services**

  Great diversity of epiphytes contributes to nutrient fixation, especially in the Andean forest zones (at 2300 and 2350 masl) (Fonseca and Ataroff 2005; Ortega Molina 2014).

Dry forest, shrublands, and deserts

2569 plant species, with a high degree of endemism. 97% of the total has been transformed (Pizano et al. 2016). Only 5.1% represented in the SINAP.

Dry forests and deserts are listed as Critically Endangered (CR) ecosystems in Colombia (Etter, 2017).

Extension in Colombia

The original cover of dry forest was 7% of Colombia's area, 8,882,854 ha;

Arid and desert areas occupy 2-3% of the total country area.

Main ecosystem services

- **Provisioning services**
  Insufficient information.
- **Cultural services**
  Alta Guajira reserve, the largest one in the country. Insufficient information
- **Support services**
  Insufficient information.

Savannahs and rocky outcrops

1% transformed. 13,7% of the total extension in SINAP, 0,3% transformed.

Extension in Colombia

8.3% of the terrestrial continental area, 9,500,000 ha; 3% of national territory are rocky outcrops

Main ecosystem services

- **Provisioning services**
  Food
  Flooded savannahs in Orinoquia: livestock activity coexists with the seasonal floods and promotes biodiversity conservation through balance between conservation and production (Peñuelas 2017).
- **Cultural services**
  Recreation.
  Cultural identity

Tropical forests

19% transformed. 16.7% extension included in the SINAP. 5,7% has been transformed.

The tropical forest ecosystems of the Llanero foothills are listed as Critically Endangered (CR) (Etter, 2017)

Extension in Colombia

Most extense ecosystems in the country: 45,363,420 ha in Amazonia and Pacific region (39.8% of terrestrial area).

Main ecosystem services

- **Regulatory services**

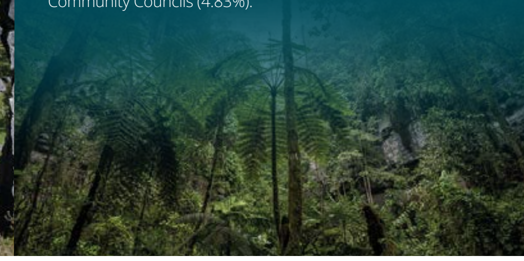
  Most mosquito species favoured by deforestation are vectors of human pathogens (Burkett-Cadena & Vittor 2018). This includes malaria vector species that are dominant in the Amazon and the Pacific (Jimenez et al. 2014; Montoya-Lertma et al. 2011). An analysis of local data for the period 2013-2017 shows that municipalities that are deforestation hotspots had an average of 15 more cases of malaria per week compared to those that are not. When discriminating by Plasmodium type (P. falciparum or P. vivax), the same pattern is observed (IPBES Colombia).
- **Cultural services**

  It is the national ecosystem with the largest proportion protected by indigenous reserve, along with collective territories of Black communities in the Pacific.
- **Support services**

  Most carbon is stored in Amazonian forests: 53% of the total carbon in Amazonas (20.8%), Caquetá (12.14%), Guainía (10.27%), and Vaupés (9.91%).

  In the Pacific region, forested areas have higher average carbon levels; the highest values can be found in the northern zone.

  The highest values of aerial carbon are found in indigenous reserves (64.16%), areas of the SPNN (18.6%), and Afro-descendant Community Councils (4.83%).



Biodiversity: :

Convention on Biological Diversity defines biological diversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

Riparian forests and floodplain ecosystems

Temporary water bodies, dependent on precipitation patterns. Their functioning depends on the synchronization, duration, and extent of flood pulses.

Flooded savannahs: Orinoquia, Casanare and Arauca departments.

Flood forests: Amazonia, seasonal floods.

Extension in Colombia

Estimated total extension: 17,861,536 ha (Jaramillo et al., 2015)

Amazon flood forests: 211,403 ha (Sinchi, 2009)

Main ecosystem services

Provisioning services

Insufficient information.

Regulatory services

Insufficient information.
Coastal erosion control
Riparian forests and vegetation also reduce erosion and filter out some of the fertilisers and contaminants from crops before they reach water courses (Olley et al. 2010; Ortega et al. 2014).

Cultural services

Insufficient information.

Support services

Nutrient recycling and soil fertility maintenance.
Habitat provision

Permanent wetlands

Permanent water bodies. 9 wetlands are Ramsar Sites, 760,340 ha.

2.3% of national territory, 2.6% has been transformed. In the SINAP, they represent 9.5% of total extension, and 5.5% has been transformed. Lake Fúquene and Lake Tota are listed as Critically Endangered (CR) due to agricultural impact (Etter, 2017).

Extension in Colombia

Estimated total extension: 4,154,524 ha, mainly the Amazon basil, Mompós Depression wetlands and margins of the San Juan and Baudó rivers (Jaramillo et al., 2015)

Amazon flood forests: 211,403 ha (Sinchi, 2009)

Main ecosystem services

Provisioning services

According to the National Authority of Aquaculture and Fisheries (AUNAP 2015), the total fishery production increased to 150,465 T, 6,2% continental fishery.

Raw materials and natural medicine.

Regulatory services

Climate and water regulation
Water purification

The role of wetlands in mitigating floods, reducing erosion, and landslides is acknowledged. Local communities associate wetland degradation with a higher flood risk (Nardini & Gomes Miguez, 2016).

Cultural services

Cultural identity of local peoples
Spiritual and recreational enjoyment (Jaramillo et al., 2015)

Support services

Habitat provision

Mangroves

Generally associated with estuary areas at river mouths (Jaramillo et al., 2015). On the Caribbean coast, at the mouths of the Magdalena River (Ciénaga Grande de Santa Marta), Sinú River, and Atrato River. On the Pacific coast, there is a more continuous area. Dominated by eight mangrove species.

21,6% of the mangrove ecosystems have been transformed. The SINAP includes 23.6%, where 8.8% has been transformed (IPBES on mining, 2019)

Extension in Colombia

Extension: 750,000 ha, 0.7% of continental territory.

Main ecosystem services

Provisioning services

According to the National Authority of Aquaculture and Fisheries (AUNAP 2015), the total fishery production increased to 150,465 T, 22,9% marine fishery. The country's most productive fishing sector in the Pacific Ocean. The fishing potential has been calculated at 37,795 tons per year, represented by 84 recorded species out of a total of 250 listed. 81% of fish populations in the region are exploited above the sustainable yield limit (SYL) (Barreto & Borda, 2008; Barreto et al. 2009; FAO & MADR, 2015).

Food security for local populations
Wood

Regulatory services

Mangrove ecosystems have great value for local communities in the protection against extreme events (Guillén et al. 2016).

Mangroves located in inland areas or separated from the sea by sand bars facilitate the dissipation of severe energy events, such as swell surge in the Caribbean or tsunami surge on the Pacific and Caribbean coasts.

Cultural services

Afro-american communities: Piangueras of the Pacific coast; community ecotourism.

Provisión de hábitat

Carbon storage: Caribbean mangroves store 2.20±0.86 Tg C above ground; Pacific mangroves around 9.61±2.78 Tg C (Bolivar et al., 2018).

Coral formations

Extension in Colombia

A total of 4,405 km2: 4,390.3 km2 in oceanic and continental areas of the Caribbean and 14.70 km2 in the Pacific

Main ecosystem services

Provisioning services

Provision of food for subsistence of fishing and commercial communities

Regulatory services

Coastal erosion control because coral reefs dissipate wave height

Coral reefs and contiguous ecosystems, such as sea grasses and mangroves, protect coasts from storms, hurricanes and tsunamis (Batista-Morales and Díaz, 2010; Prato, 2014; Polanía et al. 2015; Osorio et. al, 2018; Vanegas, Osorio and Urrego, 2019).

Cultural services

Recreation and tourism.

Support services

Habitat provision

Snorkel and diving: In San Andrés and Providencia, there is an estimated potential annual income of USD 241 million (James and Márquez, 2011). Prato and Newball (2015) estimated the economic value contributed by marine and coastal ecosystems (mangroves, sea grasses, coral reefs and open ocean) in the Seaflower Biosphere Reserve at about USD 267,339 million annually (Costanza et al. 1997; Costanza et al. 2014; Van der Ploeg and de Groot, 2010).

Sea grasses

Present only in the Caribbean, in shallow coastal areas. 85% is on the Guajira continental shelf

Extension in Colombia

66,132.47 ha; There are another 82,038.87 hectares with the potential to be colonized by pastures.

Main ecosystem services

Provisioning services

Provision of food for subsistence of fishing and commercial communities

Regulatory services

Very productive ecosystem; provides nutrients and captures nitrogen.
Atmospheric carbon sequestration and storage:
Coastal erosion control, protection against storms and gales

Cultural services

Recreation and tourism.

Provisión de hábitat

Habitat provision

CO_2

Areas with high aerial carbon are mainly concentrated in indigenous reserves (64.16%), protected areas of the National Natural Parks System (18.6%), and in the Community Council of Afro-descendant communities (4.83%). This result can serve as a guide on conservation measures or restrictions on land use that, with their implementation, could allow the permanence of forests with high carbon content.

Continued on next page

2. Ecosystems and bioculture

Update of the Red List of Terrestrial Ecosystems of Colombia (RLE)

Tool for ecosystem management

Currently, **22 ecosystems (27 %)** are **Critically Endangered (CR)** and belong mainly to dry biomes, wetlands of the Caribbean and the Andes, in addition to the forests of the plains foothills. Likewise, **14 ecosystems (17 %)** were classified as **Endangered (EN)**, located in the Magdalena Valley, the Llanero foothills and Escudo Guayanés.

It was found that, for ecosystems classified **Critically Endangered (CR)** soil degradation due to erosion, the risk of fires and infrastructure projects are threats that affect most of these ecosystems. Soil degradation due to erosion is a process that nearly **100%** of ecosystems in the **Endangered (EN)** category face. Likewise, soil degradation due to wind erosion and other types of threats threaten more than **80%** of ecosystems in **Vulnerable (VU)** category. The final evaluation shows a distribution of critically endangered ecosystems in all regions of the country, mainly in the Caribbean and the Andes. In these two regions, almost all ecosystems are at least in the Vulnerable category.

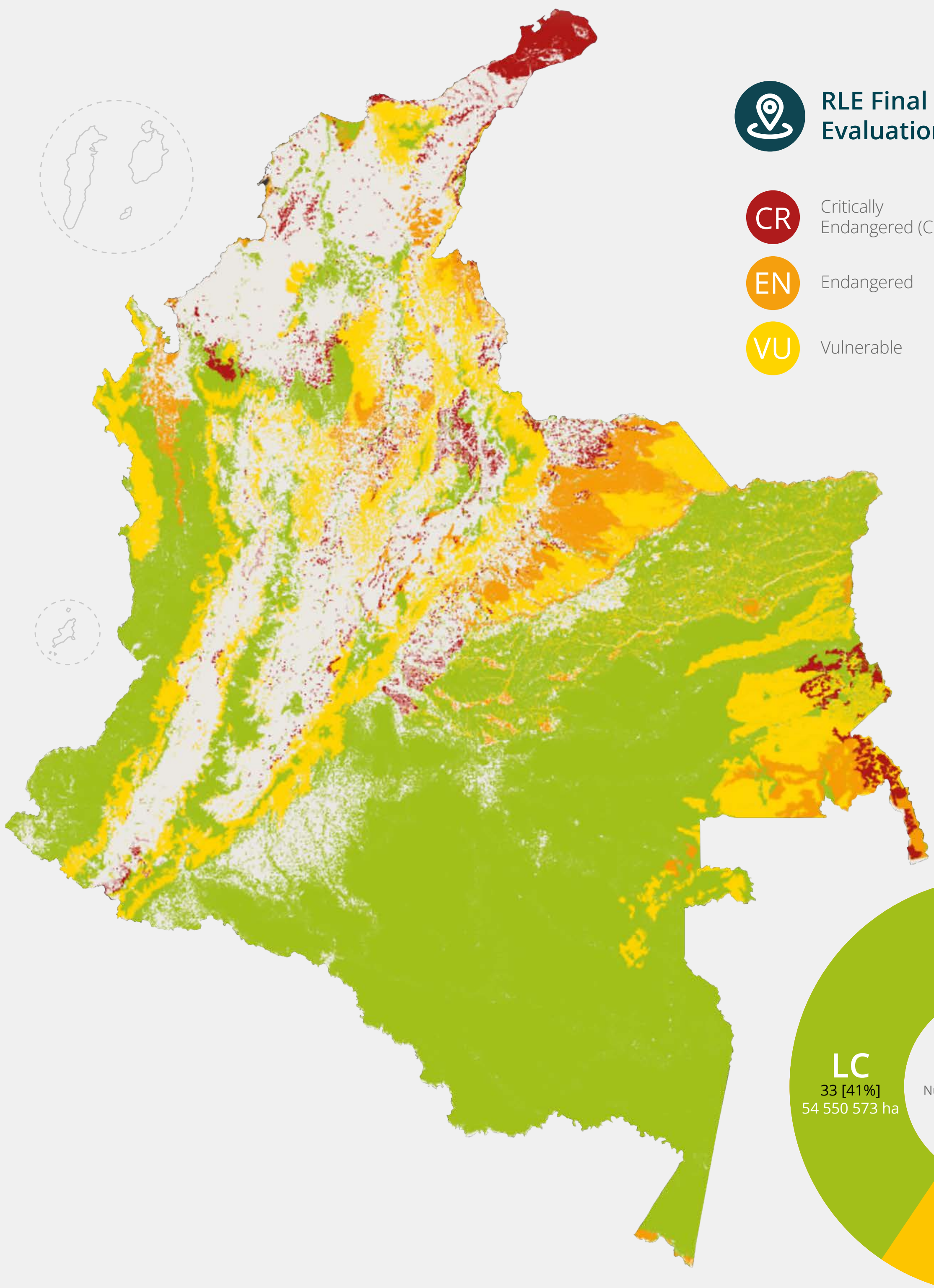
Beyond the list: applications for environmental management

In order to strengthen advanced conservation efforts, it is necessary to develop appropriate forms of ecosystem governance, including administrative and legislative instruments that guarantee the protection of those ecosystems in high risk categories. Exercises such as the RLE should be used to design policies, make decisions and guide actions.

However, the possibility of implementing the Red List of Ecosystems more broadly requires:

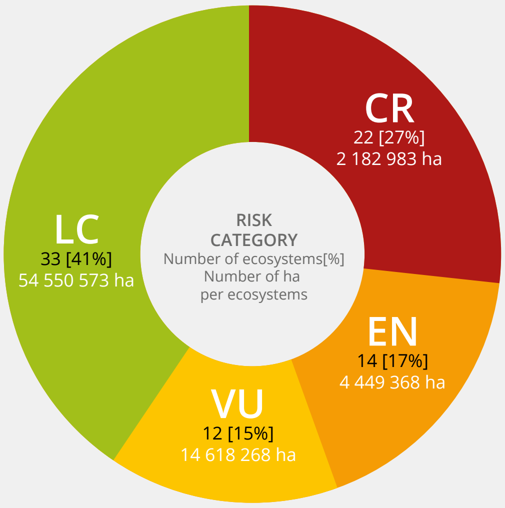
- Application in the prioritization processes of conservation areas and restoration of threatened ecosystems to strengthen the representation of ecosystems classified as CR and EN, in the National System of Protected Areas (SINAP).
- Consider the risk assessment of ecosystems in territorial planning to guide municipal development processes.
- Include areas in the threat category as criteria for the design of ecological structure nodes.
- Use risk categories in the design of specific policy for different types of ecosystems.
- Suggest projects and efforts to promote the sustainable management of resources within the territories declared as indigenous reservations and territories of Black communities, in which ecosystems in the risk category are included.
- Focus ecological restoration processes towards CR and EN ecosystems that have been impacted by the expansion process of the agricultural and urban frontier. For example, more than 50% of the transformed areas correspond to agricultural areas with a very low level of productivity. In many cases, these are ecosystems that have a high value for the representation of dry ecosystems in the Caribbean region and the forests of the Andean region.

Number, percentage and hectares of ecosystems by risk category



RLE Final Evaluation

- CR Critically Endangered (CR)
- EN Endangered
- VU Vulnerable
- LC Least Concern
- Transformed ecosystems



3. Biodiversity and ecosystem services loss crisis


The "superficial" problem
Climate change
Agroindustry
Mining (legal and illegal)
Exploitation of fishing resources
Market demand for legal and illegal products
Land grabbing
Social and economic inequality and inequity
"foundational" problem

4. Main drivers towards biodiversity transformation and nature's contributions to people in Colombia

Ecosystems

Climate change

Evidence of climate change in the country indicates an **increase in average air temperature**, ranging from +0.1 to +0.2 °C per decade since the mid-20th century, and an increase in maximum temperature of around +0.6 °C per decade, with regional variations in total annual precipitation ranging from +4% to +6%. The increment in average annual temperature has increased vulnerability in high mountain ecosystems, dry forests and island areas, mainly in these regions: Amazon, Andes and Caribbean. There is evidence that bird and amphibian species from warm areas have been migrating to higher altitudes, causing alterations in their abundance, distribution, and representation. 90% of the emergencies reported by the National System for the Management of Disaster Risk in the period 1998-2011 are related to extreme hydrometeorological phenomena, mainly associated with a detriment to forest cover in the continental territory and mangroves in coastal areas and islands.

General - all the country

Degradation and loss of habitats (terrestrial, freshwater and marine)

Changes in land use to under intensive or urbanised production systems constitute the main driver of loss of nature's contributions to society. Changes in the control of territory by the State facilitate deforestation, encouraged by speculation and land grabbing.

Deforestation is the main form of habitat degradation and loss

Its main drivers are the expansion of the agricultural frontier and/or land speculation and illicit crops, legal mining, construction of infrastructure and urban areas, and illegal logging (González et al., 2011; Armenteras et al., 2006).

Livestock farming is the main activity developed in degraded lands. The areas of livestock use represent 77% of the agricultural frontier and 27% of the entire continental territory.

Restoration has the potential to recover deforested and degraded areas; Between 2014 and 2017, Colombia restored 190,000 hectares of natural ecosystems. However, with an annual deforestation rate greater than 150,000 ha in the last years, **the loss and transformation of forests and other ecosystems continues to exceed their recovery (5.2.1.6).**

The following are the main direct causes of forest degradation

- Illegal selective logging
- Forest fires
- Shepherding in forests

(Armenteras et al., 2016; Honosuma et al., 2012; Kissinger et al., 2012). According to Pearson et al., (2017) a percentage greater than 85% of forest degradation in Colombia is the result of selective logging (for an equivalent of 15-50 MgCO2/year), and the remaining percentage corresponds to firewood collection, fires and shepherding in forests. Fires in Colombia are mostly associated with management practices to open new lands (slash and burn), and to manage pastures and crops (Armenteras et al., 2018). The areas most affected by fires are located in Los Llanos Orientales, foothills of Caquetá and Caribe, respectively (Armenteras-Pascual et al., 2011).

Soil degradation

Deforestation and poor soil management result in deterioration due to erosion in 40% of the national area. About 50% of the erosion sources are located in the Magdalena - Cauca hydrographic area.

These are the activities with the highest proportion of their area affected by erosion:

- High production commercial agriculture areas
- Agricultural areas
- Areas for agricultural use with a mosaic of crops and pastures
- Livestock areas

Without livestock activity being the one that degrades the soil the most, since **77% of the territory corresponds to productive systems used for livestock**, the largest number of hectares affected by erosion are used for this purpose.

Extractive activities associated with urbanisation considerably increase sediment transport and the degradation of terrestrial and aquatic ecosystems.

Other types of soil degradation in Colombia (without calculating the degradation level) are the **loss of organic matter and compaction caused by excessive farm work, chemical degradation due to the use of agrochemicals, salinisation due to the use of sewage for irrigation, as well as biological degradation** caused by the burning of crop residues.

Paramo ecosystems

Degradation and loss of habitats
(terrestrial, freshwater and marine)

15% degraded by **extensive livestock and agriculture activities** (mainly devoted to potatoes), gold and coal **mining**, and to a lesser extent **construction and hunting.**

Dry forest, shrublands, and deserts

Degradation and loss of habitats
(terrestrial, freshwater and marine)

The main drivers of transformation are **livestock and agriculture**. In recent years, **mining, urban development and tourism** have also become considerable agents of transformation (Pizano and García, 2014). Of the original coverage, close to 9 million hectares, only 8% remains (720,000 ha), distributed in mosaics of heterogeneous and fragmented landscapes (González et al., 2018).

Permanent wetlands

Degradation and loss of habitats
(terrestrial, freshwater and marine)

The growth of cities has led to the direct loss of urban wetlands. Between 1950 and 2016, Bogotá lost 84.52% of the total area of its wetlands. In the last decades, Cali lost more than 90%.

Andean forests

Degradation and loss of habitats
(terrestrial, freshwater and marine)

Two of the **12 deforestation hotspots identified in 2019 are in the Andean region:** north-central (Antioquia and South of Bolívar) and North (Catatumbo)

Savannahs and rocky outcrops

Degradation and loss of habitats
(terrestrial, freshwater and marine)

Deforestation for livestock expansión

Tropical forests

Degradation and loss of habitats
(terrestrial, freshwater and marine)

Deforestation, carried out to implement new uses of the land or as a way to guarantee possession of the land, favored by multiple indirect factors. **The Amazon region has the highest deforestation rates.** More than 70% of the country's total deforestation took place in the Amazon region (138,176 ha). By 2019, 6 of the twelve main deforestation centers were in this region and 3 in the Pacific region.

There is no information on deforestation linked to illegal mining. Information on deforestation related to legal concessions is scarce, and it is not provided periodically for monitoring.

Continued on next page

4. Main drivers towards biodiversity transformation and nature's contributions to people in Colombia

Average human footprint

55% of the paramos in Colombia are still waiting to have some kind of protection or conservation status (Sarmiento et al., 2017). The moors present a transformation of 15.5% and, of those present in protected areas, 7% are transformed (IPBES Minero, 2019).

Infographic references

Infographic 1. Species and genetic diversity

Colombia compared with the rest of the world: https://cifras.biodiversidad.co/

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Infographic 2. Ecosystems and bioculture

Update of the Red List of Terrestrial Ecosystems of Colombia (RLE):

http://reporte.humboldt.org.co/biodiversidad/2017/cap2/204/#seccion4

Andrade et al., 2017 RET Worksheet 104

1 Presentation

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

This Platform, with 130 current member States, was established in 2012 by a United Nations resolution as an independent intergovernmental body seeking to strengthen the link between science, policy and society. Consequently, it provides policymakers the knowledge gathered in the global and regional assessments that it conducts, and in the scientific processes related to the conservation, use, and sustainable management of biodiversity and its relationship with sustainable development and human wellbeing. IPBES provides technically rigorous and scientifically valid information, under a principle of broad social, multisectoral, and interinstitutional participation.

Colombia, one of the 12 countries globally classified as megadiverse (infographic 1) by hosting around 10% of known species (Environmental Information System of Colombia [SIAC], 2021)[1] and widely recognised for its biocultural diversity, was one of the first countries selected in 2017 to carry out a National Biodiversity Assessment within the framework of IPBES, along with Ethiopia, Vietnam, and Cameroon. Furthermore, in 2019, at the seventh plenary of the intergovernmental platform for biodiversity and ecosystem services (IPBES-7) held at the end of April in Paris, Ana María Hernández, then Head of the Office of International Affairs, Policy, and Cooperation of the Alexander von Humboldt Institute, was elected as President of IPBES for a term of three years.

National assessments, such as the one conducted by Colombia, also address Decision 14/1 of the Conference of the Parties to the Convention on Biological Diversity (CBD), inviting governments to conduct assessments on biodiversity and the country's ecosystem functions and services (CBD, 2021). This assessment is of particular relevance and opportunity for Colombia, as this year at the Fifteenth meeting of the Conference of the Parties to the Convention on Biological Diversity, hosted in Kunming (China) in October 2021, governments will adopt a new Global Biodiversity Framework post-2020 to address the critical global situation of nature and the necessary measures to ensure life-supporting systems on the planet. According to the theory of change supporting the Post-2020 Framework with its new Targets for 2030 and Vision for 2050, *"urgent policy action globally, regionally and nationally is required to transform economic, social and financial models so that the trends that have exacerbated biodiversity loss will stabilise in the next 10 years (by 2030) and allow for the recovery of natural ecosystems in the following 20 years, with net improvements by 2050 to achieve the Convention's vision of 'living in harmony with nature by 2050'."*

Together with Ethiopia, Vietnam and Cameroon, Colombia was selected to conduct a national ecosystem assessment process following the methodology established by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

1 Environmental Information System of Colombia (SIAC, Jan 29 2021). Biodiversidad en Colombia [Biodiversity in Colombia]. http://www.siac.gov.co/biodiversidad#:~:text=El%20territorio%20colombiano%20alberga%20cerca,la%20biodiversidad%20en%20la%20Tierra.

Colombia's National Biodiversity and Ecosystem Assessment

Colombia's National Biodiversity and Ecosystem Assessment, which should be considered relevant until 2050, provides strategic information on biodiversity condition and tendencies regarding human wellbeing in Colombia. On the one hand, it aims to provide a clearer approach in political spheres by characterising where we come from in terms of the condition and modifications of nature's attributes (see Chapter 1, on natural capital, goods and services of nature) and society, and the reciprocity between the two (see Chapters 3-6). On the other hand, it seeks to illustrate where we are going, in terms of change trajectories and possible futures (see Chapter 7, Figure 1).

The National Assessment formally began in October 2017. A total of 106 experts from different disciplines and regions participated, operating independently from government bodies, institutions, and organisations, to carry out the compilation and analysis of several sources of information such as scientific publications, research project results, academic research, and official country reports, among others. The participation of experts from indigenous, Afro-descendant, Black, peasant, islander, and other local communities is highlighted, since it enriched the analysis with diverse world views, values, and knowledge systems. Recently, the Secretariat of the Convention on Biological Diversity (CBD, 2021) highlighted two aspects of the Colombian procedure:

1. The integration of knowledge and views from *indigenous peoples and local communities* through the implementation of the "Trialogue" methodology developed by the Biodiversity and Ecosystem Services Network (BES-Net, see Chapter 4). To date, no other country has undertaken a similar process, making it the only assessment that includes a specific chapter on this topic. Therefore, BES-Net proposes to develop a guide to support this integration based on the Colombian experience.

2. The adoption of digital consultation arenas with the general public during the development of the national assessment. Throughout the process, drafts of several assessment documents and the Summary for Policymakers (SPM) were published to gather comments and other contributions, as follows:

   - Project scope document (Sept-Oct 2018): 12 people made 41 contributions and comments.
   - First draft of chapters (April 2019): 15 people made 74 contributions and comments.
   - Second draft of chapters (July-Aug 2019): 22 people made 131 contributions and comments.
   - Final documents (Jan-Feb 2020): 17 people made 236 contributions and comments.
   - First draft of the Summary for Policymakers (SPM) (May-June 2020): 32 people made 331 contributions and comments.

This compilation and analysis of information enabled the authors to identify a series of findings and to generate conclusions and recommendations to support the formulation and implementation of policies and the development of capacities required to strengthen the science-policy interface in Colombia. This is in response to the challenge of protecting and conserving its biocultural heritage, ensuring the environmental sustainability of its territories, and providing ecosystem services for the wellbeing of society.

Figure 1. Titles of the seven chapters that are part of Colombia's National Biodiversity and Ecosystem Assessment

Chapter 1: Colombia's National Biodiversity and Ecosystem Assessment in the context of IPBES

Chapter 2: Biodiversity condition in Colombia

Chapter 3: Nature's contributions to people

Chapter 4: Biocultural diversity: Knowledge and best practices to support life in indigenous and local communities territories

Chapter 5: Direct drivers for the transformation and loss of biodiversity and nature's contributions to people

Chapter 6: Policies, institutions and governance

Chapter 7: Future scenarios for biodiversity and ecosystem services in Colombia

Summary for Policymakers (SPM)

This document presents four key messages, built from a broad vision of the country that encompasses all sectors and is enriched by the different perspectives and topics developed in the six technical chapters of Colombia's National Biodiversity and Ecosystem Assessment. In each of these chapters, the authors have identified and formulated the key findings that underpin each of the four key messages presented. Additionally, each key message includes some of the conclusions and recommendations from Colombia's Sixth National Report submitted to the Convention on Biological Diversity (CBD) (Minambiente et al., 2019[2]), relative to progress in achieving the Aichi Biodiversity Targets established in the CBD's Strategic Plan for Biological Diversity 2011-2020.

Needless to say, as it name indicates, policymakers. After several discussions throughout the assessment, it was agreed that the term ***policymakers*** includes not only national-level State actors that establish the national political and legal framework, but also comprises local and regional actors, from the public and private sector, and organised communities. These stakeholders, in one way or another, influence biodiversity and nature's contributions to people. In fact, for this assessment, the term ***biodiversity and ecosystem services governance*** encompasses all interactions among public institutions, the productive sector, social organizations, civil society, standards, regulations, decision-making processes and procedures, accountability, and organisations that work with socio-environmental problems and are capable of addressing ecological and social change while fostering socio-ecological transitions towards sustainability (TSS)[3]. Therefore, these four messages are valid and even more relevant at the regional and local level, since governance is to be executed in these areas and it is where decisions are implemented and impact biodiversity and ecosystem services, which are closely linked to human wellbeing in Colombia, either positively or negatively.

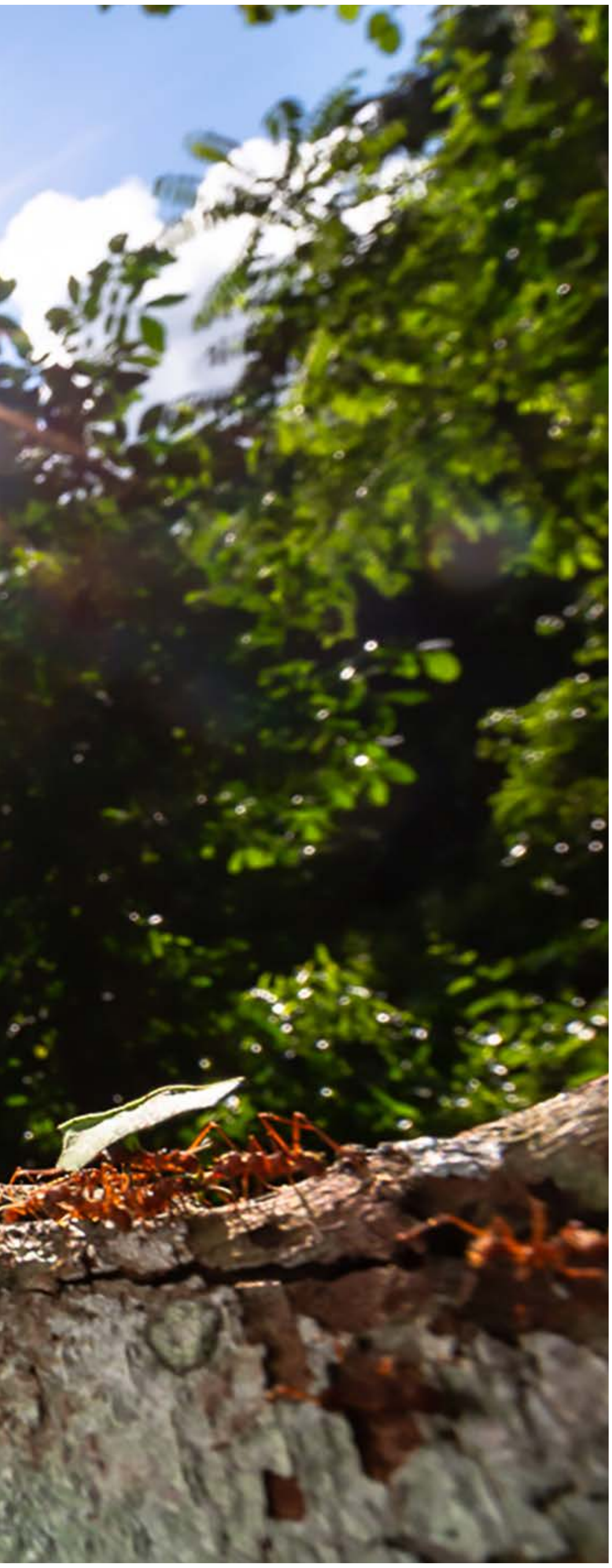
[2] Ministry of Environment and Sustainable Development, United Nations Development Programme, and Colombian Chancellorship. 2019. Sixth National Report from Colombia to the Convention on Biological Diversity. 294 p.

[3] Socio-ecological transitions towards sustainability are defined as "biodiversity management processes that are appropriate and driven by social actors, aiming to modify the undesirable change trajectory in the ecological and social system to guide it through concerted actions towards a state that maximises the wellbeing of the population and environmental security of the territory" (Andrade G. I., M. E. Chaves, G. Corzo and C. Tapia (eds.). 2018. Transiciones socioecológicas hacia la sostenibilidad. Gestión de la biodiversidad en los procesos de cambio en el territorio continental colombiano. Primera aproximación. [Socioecological transitions towards sustainability. Biodiversity management in the processes of change in the Colombian mainland territory. Preliminary approach.] Bogotá: Alexander von Humboldt Biological Resources Research Institute. 220 p.)

... the authors have identified and formulated the key findings that underpin each of the four key messages hereby presented.

2 Acknowledgements

Many months of work have resulted in a document rich in knowledge, conceptual discussions, data, but above all, commitment and passion for the biological and cultural diversity of a megadiverse country like ours.



The Co-Chairs of Colombia’s National Biodiversity and Ecosystem Assessment would like to kindly thank both individuals and institutions that made the elaboration of this report possible. To Ana María Hernández and Brigitte Baptiste, who, from the global IPBES, conceived the idea of an assessment for Colombia some years ago. To the World Conservation Monitoring Centre (WCMC), which has been the guarantor and coordinator of all national IPBES assessments at a global scale, always closely connected with our progress and facilitators of innovative methodologies, especially in the context of Indigenous and Local Knowledge (ILK). To the Ministry of Environment and Sustainable Development and the research institutes of the National Environmental System, who have actively participated in contributing to and providing feedback on the general assessment document and the summary for policymakers. We appreciate the support of the advisory group of the Colombia Assessment, who provided key information in the drafting of the document. A special mention of the ongoing support from the Alexander von Humboldt Institute under the leadership of its director, Hernando García, who has provided spaces, professionals, time, and financial management to achieve this document.

This summary, based on the technical document of Colombia’s National Biodiversity and Ecosystem Assessment, would not have been possible without the support of experts in several areas of ecological and social knowledge, policy experts, and particularly our collaborators who have contributed scientific, indigenous, Afro-descendant, and peasant knowledge both in the assessment and in this summary. Many months of work have resulted in a document rich in knowledge, conceptual discussions, data, but above all, commitment and passion for the biological and cultural diversity of a megadiverse country like ours.

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Thanks to all of them, we now have the honour of having an independent, concise, and robust document on the condition of biodiversity in Colombia, which we hope will influence many decision-making processes from our country.

Clara Solano and Wilson Ramírez

3 Key Messages

Key Message 1: Colombia is a megadiverse, multi-ethnic, and multicultural country, and the wellbeing of its people is truly tied to nature, but it is not properly known and valued.

Understanding nature's relevance and significance for the quality of life of people and valuing it as the primary asset for development requires going beyond the economic notion and recognising the plurality of values.

While significant efforts have been made over time to understand Colombia's megadiversity from scientific perspectives, especially in the last 25 years with new research institutes associated to the Ministry of Environment and Sustainable Development, scientific knowledge about biological diversity in the country is still incipient, even when we consider only the different species present in the country. At the genetic and functional level, our knowledge of Colombian diversity is more limited.

It is estimated that around 35% of the Colombian population directly benefits from water derived from high mountain ecosystems, such as cloud forests and paramos.

Despite this lack of knowledge, it is considered that the country's natural capital, understood as the stock of natural assets, represents 12% of its total wealth (Lange *et al.*, 2018[4]). Nonetheless, even though this number shows the importance of nature, it only provides a partial view of nature's contribution to the country's economic and social development and the wellbeing of its people. It is an underestimation for, at least, two reasons. Firstly, because it only captures the economic value that is mainly manifested in market transactions. Secondly, because it only captures one of the several value dimensions, the economic one; but even within the economic dimension, knowledge is scarce and fragmented, giving limited recognition to some material contributions (goods, such as timber and non-timber forest products, for example) and contributions to natural balance (air, water, and soil quality, flood and disease control, among others).

The current emphasis on the economic value of biodiversity and nature's contributions to human wellbeing prioritises the instrumental values of nature, overlooking other forms of valuation that may be particularly important for indigenous, Afro-descendant, Black, rural, and other local communities. Therefore, Colombia needs a plural and comprehensive valuation that includes different perspectives, given its ethnic and cultural diversity. Hence, the term ***biocultural*** highlights and denotes the complex interrelation between the nation's cultural diversity and territorial diversity and biodiversity, through knowledge systems and best practices for their care.

Acknowledging the importance of going beyond economic value, the National Policy for the Integral Management of Biodiversity and Its Ecosystem Services (PNGIBSE) (Minambiente, 2012[5]) strategically proposes developing comprehensive valuation schemes and instruments/tools to be incorporated into environmental management documents. Furthermore, there remains the challenge of integrating information and knowledge in multidimensional, multiscale, and transdisciplinary

4 Lange, Glenn-Marie, Quentin Wodon, and Kevin Carey, eds. 2018. The Changing Wealth of Nations 2018: Building a Sustainable Future. Washington, DC: World Bank. doi:10.1596/978-1-4648-1046-6.

5 Ministry of Environment and Sustainable Development (2012). "Política Nacional de Gestión Integral de la Biodiversidad y sus Servicios Ecosistémicos" [National Policy on Integral Management of Biodiversity and Ecosystem Services]. 128 pp.

ways to follow trends and changes in the nation's natural heritage steadily. This should enable systematic access to data for decision-making through the generation, management, and use of different kinds of information and knowledge —all processes that need to be strengthened. The incorporation of knowledge about natural systems should also contribute to integrating sectoral actions and biodiversity dynamics so that (sectoral) decisions taken do not harm the natural heritage. In this context, academia plays a very important role as a point of contact, empowerment, and central support for different actors, especially at the local level. Academia often lays the grounds for continuity of processes in the territory; however, its underfunding and sometimes insufficient technical capacity are areas for improvement. While it is important to move forward incorporating plural and comprehensive valuation in collective decision-making processes, it is important to seek mechanisms that allow breaking the dichotomy between "political times" and the times required for long-term research for the construction of lasting processes (Rincón et al., 2019a[6]).

Key findings

Acknowledging and integrating the non-economic value of nature, i.e. producing a plural and comprehensive valuation, is key to bring marginalised groups into the discussion and decision-making; it would also reduce power assymetries that remain a structural constraint for access and distribution of ecosystem services and strengthen environmental justice *(Well established).* Our country's biocultural diversity relies on the coexistence of different ways of understanding and engaging with nature. The current emphasis on the economic valuation priories nature's instrumental contribution, overlooking other visions that could be particularly important for indigenous, Afro-descendant, Black, Raizales, rural, and other local communities. Recognising the importance of surpassing economic value, the National Policy for Biodiversity Management and its Ecosystem Services (PNGIBSE) proposes as a strategic line the development of comprehensive valuation schemes and resources to be incorporated into environmental management instruments (3.3.1; 3.3.2; 3.4). Eventually, these comprehensive valuation processes will contribute to the consolidation of biodiversity change scenarios and contributions to wellbeing.

People depend on biodiversity for their daily life, but this is not always evident or valued. Human health depends on essential ecosystem goods and services such as freshwater, food, and fuel sources, as well as intangible aspects of nature. Therefore, biodiversity loss can have a significant direct impact on human health if ecosystem services no longer meet social needs. Indirectly, changes in ecosystem services affect livelihoods and income sources, contribute to local migration, and sometimes even cause social conflicts (WHO, 2020[7]). In the case of Colombia, the numbers speak for themselves. It is estimated that the Colombian population annually loses 3.3 years of life due to environmental factors, translating into a cost of almost COP10 trillion a year (Huertas, 2015[8]). In fact, air and water pollution caused 7,600 premature deaths in 2010, with costs adding up to 2% of the annual GDP. In addition, diversity of microorganisms, flora, and fauna provides significant benefits for biology, health sciences, and pharmacology. A deeper understanding of biodiversity can lead to significant medical and pharmacological discoveries; its loss can limit the discovery of treatments for different diseases (WHO, 2020).

Nature plays a direct and relevant role to support the country's production and employment *(Well established).* At least 10% of the GDP is directly derived from the exploitation of natural resources, and around 14% of employment depends on agricultural and fishing activities. This means that a significant portion of the Colombian population directly depends on nature. However, a high proportion of this population lives in conditions of monetary poverty, 42% in 2019[9], and is vulnerable to ecosystem degradation. The systematic, decisive, and long-term articulation and implementation of green growth policies and strategies, circular economy, biotrade, and green markets, as well as the recognition of knowledge and community governance systems as environmental institutions, could encourage the generation of an economy where conservation and development are complementary rather than antagonistic (3.2.6; 3.2.10; 3.3.2).

6 Rincón-Ruiz A., Arias-Arévalo, P., Núñez Hernández, J.M., Cotler, H., Aguado Caso, M., Meli, P., Tauro, A., Ávila Akerberg, V., Avila-Foucat, S., Cardenas, J., Castillo Hernádez, L.A., Castro, L., Hernández, C., Contreras Araque, A., Deschamps-Lomeli, J., Galeana-Pizaña, J.M., Oñate, K., Hernández Aguilar, J.A., Jimenez, A.D., López Mathamba, L.A., Márquez Pérez, L., Moreno Díaz, M.L., Marín Marín, W., Ochoa, V., Sarmiento, M.A., Díaz Timote, J., Tique Cardozo, L.L., Trujillo Acosta, A. & Waldron, T. (2019a). Applying integrated valuation of ecosystem services in Latin America: Insights from 21 case studies. Ecosystem Services 36.100901

7 World Health Organization. (2020). WHO Director-General's opening remarks at the COVID-19 media briefing. World Health Organization (OMS), 03-11-2020, retrieved on 15-02-2021, available at https://www.who.int/es/director-general/ speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefingon-covid-19, 11-march-2020

8 Huertas, J (2015). in "Proposal to Establish an Environmental Contaminants Surveillance System in Colombia." Biomédica [online]. Revista del Instituto Nacional de Salud, vol. 35 (suplem. 2), 2015, pp. 8-19. Bogotá: Ministry of Environment, Housing and Territorial Development. Available at: http://www.scielo.org.co/pdf/bio/v35nspe/v35nspea02.pdf)

9 Our own calculations based on GEIH 2019, DANE data. It corresponds to the proportion of employed individuals in agricultural activities that are in monetary poverty.

Growing pressure of economic activity on the environment and territory is associated to the increase of environmental conflicts *(Well established).* Excluding diverse valuation languages from decision-making processes, ways people conceive and express their relationship with nature and the importance it holds for them, leads to environmental conflicts (Figure 1; 3.4).

Approaches based on local organisation and empowerment have been effective paths towards better decision-making, even more inclusive ones (Section 3.4). Strengthening participation and consultation in processes that define interventions on the territory, such as environmental licensing, can help reduce conflict. There was an important tool to support participation, which was later on eliminated, used for Strategic Environmental Assessments (SEA). It was used to carry out sector-specific analyses in production, and regional analyses for certain regions or sensitive ecosystems characterised by a saturation of large projects. These comprehensive assessments enabled understanding the aggregated impact and the best measures to prevent, mitigate, and compensate them.

Illegal activities related to illicit crops also lead to conflict. Figure 2 shows an analysis of deforestation rates associated with coca cultivation and other reasons in each region (Box 5.1) Armenteras et al. (2011, 2013[10]) established that there are additional factors that determine deforestation rates other than coca cultivation. Thus, their analysis includes variables such as urban population density, initial proportion of forest, proportion of the population with unmet basic needs, and the total area eradicated by spraying between 1999 and 2005. Modelling showed that population density and coca cultivation were not significant factors for deforestation, whereas the others were. For instance, in the model, deforestation rates, apart from coca cultivation, may be explained by factors such as urban population density, initial forest coverage, proportion of the population with unmet basic needs, and the total area eradicated by spraying during the period 1999-2005.

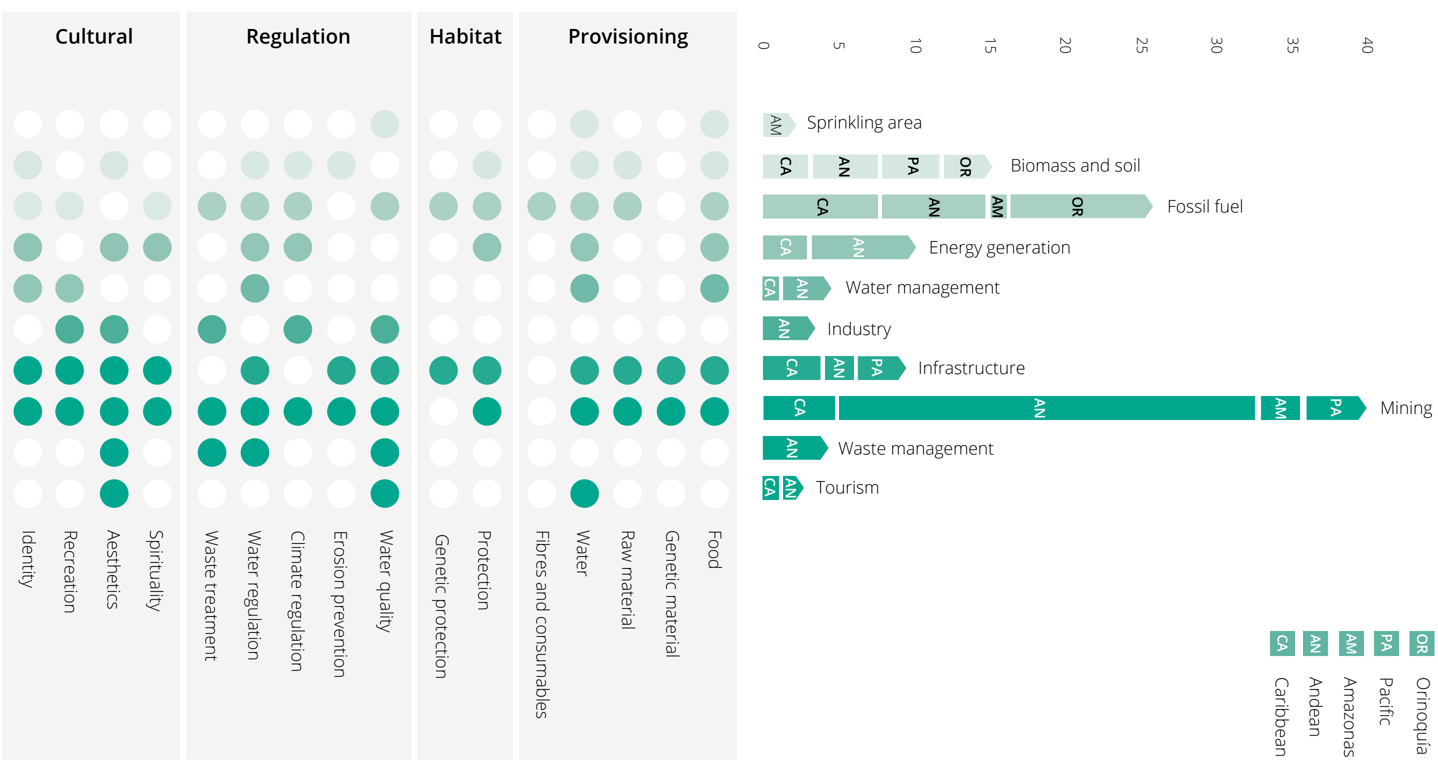


Figure 1. Environmental conflicts in Colombia according to the different ecosystem services affected and their geographic location (Rincón-Ruiz et al., 2019[11]).

[10] Armenteras, D., Rodríguez, N., Retana, J., Morales, M. (2011). Understanding deforestation in montane and lowland forests of the Colombian Andes. Regional Environmental Change, 11:693–705. http://dx.doi.org/10.1007/s10113-010-0200-y
Armenteras, D., Cabrera, E., Rodríguez, N., & Retana, J. (2013). National and regional determinants of tropical deforestation in Colombia. Regional Environmental Change, 13(6), 1181–1193. https://doi.org/10.1007/s10113-013-0433-7

[11] Rincón-Ruiz A., Rojas-Padilla J., Agudelo-Rico, Perez-Rincon M., Vieira Samper S., Rubiano J. 2019. Ecosystem services as an inclusive social met

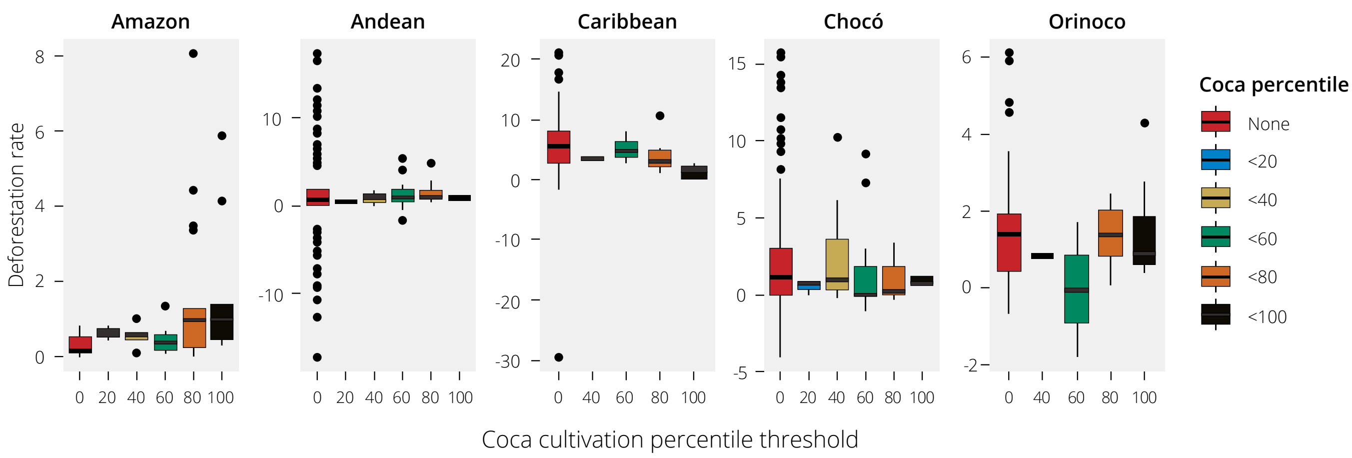


Figure 2. Summary of deforestation rates by coca cultivation percentile per region (based on Armenteras et al., 2011 and Armenteras et al., 2013)

Pollination services significantly determine Colombian food security and nutrition *(Established but incomplete).* In addition to subsistence crops, many commercial crops directly or indirectly depend on animal pollination, including coffee (*Coffea arabica* L.), ahuyama [pumpkin] (*Cucurbita moschata* Duchesne), guava fruit (*Psidium guajava* L), granadilla, and other Passifloras (*Passiflora edulis* Sims, *P. ligularis* Juss). Despite the importance of this service, very few studies have evaluated the interactions between plants and pollinators or the pollination service itself. Although there is currently no economic assessment of pollination services at the national level, the available information provides a glimpse into the importance of pollinators to the country's economy. For example, a study in Santander found that insect pollination increases Colombian coffee production by around 10%. Therefore, the absence of pollinators translates into a loss of approximately 5.4% of net income per hectare for the producer.

Pollinator contribution to some promising Colombian crops is also significant. For instance, cholupa crops (*Passiflora maliformis*) is 27% benefited from insect pollination, while the agraz (*Vaccinium meridionale* Swartz) is 50-65% benefited. This means that for every kilogram of agraz, a profit of between COP800 and COP900 is obtained as a result of insect pollination. In the case of cholupa, this represents around COP5 million per hectare. In recognition of their importance, Colombia formulated a National Strategy of Pollinators; yet, although it has been available for five years, this Strategy has not yet been adopted and incorporated into different planning instruments such as National, Departmental, and Municipal Development Plans, Territorial Ordering Plans, and other relevant public policies, in order to coordinate the efforts of particular institutions and the resources needed for its effective implementation (3.2.1).

Pollinator contribution to some promising Colombian crops is also significant.

Forests contribute to water quality by retaining contaminants. Additionally, riparian forests and vegetation also reduce erosion and filter out some of the fertilisers and contaminants from crops before they reach water courses *(Well established).* Forests have low concentrations of dissolved nutrients in water, indicating good water quality at the groundwater level of conserved soils. The hydroclimatic ecological conditions of the forest determine the dynamics of nutrient flow entering drainage basins through precipitation, with nitrogen (in the form of nitrates NO_3) being the predominant input in different life zones and according to the types of cover. In Antioquia, for instance, secondary forest has the highest surface infiltration value at 3606.87 mm/year, followed by clean cultivation (1670.94 mm/year), pasture (1562.22 mm/year), and primary forest (103.81 mm/year). The processes that favour this high infiltration also contribute to the removal of pollutants, thus forest cover promotes both the regulation of water supply and its quality. However, more information is needed about nutrient loss in native forest coverages (3.2.5).

In Colombia, most carbon stored in forests can be found in the Amazon and Andean regions *(Well established).* However, the Pacific region holds forests with one of the highest average carbon assimilation rates, despite being the region with the smallest total area (seven million hectares). Four departments store almost 53% of the country's CO2 found in forests: Amazon (20.8% of the total), Caquetá (12.14 %), Guainía (10.27%), and Vaupés (9.91%). Areas with high contribution of above-ground biomass storage are mainly concentrated in indigenous reserves (64.16%), protected areas of the National Natural Parks System (18.6%), and in the Community Council of Black Communities (4.83%). In general terms, the areas with highest forest conservation coincide with territories where indigenous, Afro-descendant, Black, Raizales, rural, and other local communities develop their own systems of governance and management (3.2.2; 4.1.1).

Highly conserved upper drainage basins and their protected areas retain sediments that promote hydroelectric power generation and reduce water treatment costs for aqueducts. *(Well established).* It is estimated that around 35% of the Colombian population directly benefits from water regulation derived from the functioning of high mountain ecosystems, such as cloud forests and paramos (a type of alpine tundra). Similarly, protected areas contribute to erosion control. Highly conserved upper drainage basins, and basins that are part of protected areas, retain sediments that promote hydroelectric development, power generation, and reduce water treatment costs for aqueducts. For instance, conserving the upper Chinchiná River basin in Los Nevados National Natural Park prevents the export of an additional 1.48 million tons of sediment, resulting in annual savings of $3.286 million for sediment removal in the hydroelectric sector (average year, climate normal,

1980-2015; tons of sediment/year) (National Natural Parks, 2016[12]). Deforestation in protected areas, however, threatens these contributions. It is necessary to strengthen incentives for the conservation of upper drainage basins to control erosion, and support the provision of water in the necessary quantity and quality different uses demand (3.2.4; Box 3.2).

Wetlands, mangroves, and coral reefs are key ecosystems in Colombia for mitigating the effects of climate change and extreme events. The loss of these ecosystems increases the vulnerability and risk of flooding for lower income families *(Well established).* In Colombia, the most frequent events that affect the largest number of people are floods (Aguilar et al., 2008[13]). Wetland loss makes this situation even worse. Around 24% of the country's wetlands have been transformed (Jaramillo et al., 2015 & 2016). In areas with periodic flooding, such as La Mojana, this transformation rate exceeds 40%. The proximate causes of transformation are identified as mining, agricultural activities, infrastructure development, and extensive livestock farming. It is calculated that almost 50% of the transformed land from wetlands is associated to this last activity (Jaramillo et al., 2015 & 2016[14], Ricaurte et. al., 2017[15]) (Section 3.2.7). Coral reefs, on the other hand, mitigate coastal erosion by 55% to 94%, and can reduce wave height by 85% to 92% (Osorio-Cano et al., 2018[16]). Coral reefs and adjacent ecosystems such as seagrasses and mangroves protect coasts from erosion and extreme weather events like storms, hurricanes, tsunamis, and sea level rise (Prato, 2014[17]; Polanía et al., 2015[18]; Osorio et al., 2016[19]) (3.2.7).

12 PNN. (2016). Assessment of the Ecosystem Service of Sediment Retention in the Chinchiná River Basin (CRB), Los Nevados National Natural Park. Bogotá D.C.: National Natural Parks System of Colombia - Subdirectorate of Sustainability and Environmental Business. Retrieved from https://www.parquesnacionales.gov.co/portal/wp-content/uploads/2018/08/Informe-de-valoracion-SE-hidrologico-PNN-Nevados-1.pdf

13 Aguilar, A., Bedoya, G., Hermelin, M. (2008). Inventario de los desastres de origen natural en Colombia, 1970-2006-: limitantes, tendencias y necesidades futuras. [Inventory of Natural Disasters in Colombia, 1970-2006 - Limitations, Trends and Future Needs] Gestión y Ambiente, 11(1).

14 Jaramillo, U., Cortés-Duque, J. and Flórez, C. 2015. Colombia anfibia. Un país de humedales. [Amphibian Colombia. A Country of Wetlands.] Volume I. Alexander von Humboldt Biological Resources Research Institute. Bogotá D.C., Colombia. 140p.
Jaramillo, U., Cortés-Duque, J. and Flórez, C. 2016. Colombia Anfibia. Un país de humedales. [Amphibian Colombia. A Country of Wetlands.] Volume II. Alexander von Humboldt Biological Resources Research Institute. Bogotá, D. C., Colombia. 116p.

15 Ricaurte, L., Olaya-Rodriguez, M., Cepeda-Valencia, J., Lara, D., Arroyave-Suárez, J., Finlayson, C., Palomo, I., (2017). Future impacts of drivers of change on wetland ecosystem services in Colombia. Global Environmental Change. 44, 158-169

16 Osorio-Cano, J.D., Alcérreca-Huerta, J.C., Osorio, A.F. (2018) CFD modelling of wave damping over a fringing reef in the Colombian Caribbean. Coral Reefs 37, 1093–1108. https://doi.org/10.1007/s00338-018-1736-4

In an urban context, there is increasing recognition that green spaces, urban forests, and street trees can contribute to improving air quality by reducing pollutant concentrations (Well established). Globally, it is recognised that air pollutants emitted in one region (e.g., from industrial activities or forest/biomass burning) can circulate to other regions, contributing to negative effects on human health and crop damage (Akimoto, 2003[20]; Hollaway et al., 2012[21]). Thus, Londoño and collaborators (2016[22]) show the contribution of green areas near emission sources and industrial areas to reduce PM concentration$_{10}$[23]. It is worth highlighting that nature-based solutions to improve air quality can be cost-effective, especially because air quality is a valued attribute by citizens who are willing to pay for its improvement. In fact, Carriazo and Gómez-Mahecha (2018)[24] estimate that households in Bogotá would be willing to pay a monthly sum of USD12.6 to reduce PM concentration$_{10}$ from 51.8 µg/m3 to 50 µg/m3, thus complying with national standards (3.2.3).

At present, over half of the global population lives in cities, and it is estimated that by 2050, this proportion could increase to 70% of the human population. Colombia is one of the countries where this increase could be even higher, surpassing 85%. Urban living offers technological, social, and economic advantages. Yet, however protected, wealthy, and powerful cities may seem, they can be particularly vulnerable to diseases and climate impacts. Urban heat islands, exacerbated by climate change, translate into high-risk habitats for dengue vector mosquitoes in Southeast Asia, Africa, and Latin America, and have driven significant outbreak cycles. In northern latitudes, there vertebrate reservoirs in city parks and gardens; large populations of hedgehogs, rats, and squirrels often live close to humans, posing a high risk to human health as these species can carry zoonotic diseases. In South America, urban areas pose a high risk of canine visceral leishmaniasis (CVL) and human leishmaniasis due to the presence of vector mosquitoes and large populations of wild or stray dogs. The overlapping distribution of urban and forest mosquitoes at the edges of parks increases the risk of arbovirus exchange through multiple bridge vectors in urban forest parks in Brazil. These risks are often mitigated through enhanced disease control systems to protect, treat, and assist urban residents in recovering from infectious diseases in urban regions (IPBES, 2020[25]).

Organisms and ecosystems assist in the regulation of pests, pathogens, predators, competitors affecting humans, and other species of fauna and flora. A clear example could be the relationship between deforestation and the incidence of malaria. According to Burkett-Cadena & Vittor (2018)[26], most mosquito species favoured by deforestation are vectors of human pathogens, including malaria vectors predominant in the Amazon and Colombian Pacific regions (Jiménez et al., 2014[27]; Montoya-Lerma et al., 2011[28]). An analysis of local data[29] for the period 2013-2017 shows that municipalities that are active deforestation areas had an average of 15 more cases of malaria per week compared to those that are not. When discriminating by Plasmodium type (*P. falciparum* or *P. vivax*), the same pattern is observed. Similarly, biological control of invasive pests that have a negative impact on commercially relevant crops is a significant contribution in the Colombian context. In commercially relevant crops such as coffee, sugarcane, and flowers, integral pest management through biological control allows producers to reduce production costs by using fewer pesticides while

17 Prato J.A. 2014. Importancia económica de nuestros mares: Capital natural marino y costero de Colombia. [Economic Relevance of our Seas: Natural Capital of the Colombian Coastal and Marine Systems] La Timonera, 22: 32-37.
18 Polanía, J., Urrego, L.E., and Agudelo, C.M. 2015. Recent advances in understanding Colombian mangroves. Acta Oecologica 63: 82-90.
19 Osorio A.F., Ortega S., Arango-Aramburo, S. 2016. Assessment of the marine power potential in Colombia. Renewable and Sustainable Energy Reviews, 53: 966-977. Doi:10.1016/j.rser.2015.09.057
20 Akimoto, H. 2003. Global air quality and pollution. Science 302(5651):1716-1719.
21 Hollaway, Michael & Arnold, S. & Challinor, Andrew & Emberson, Lisa. (2012). Intercontinental trans-boundary contributions to ozone-induced crop yield losses in the Northern Hemisphere. Biogeosciences. 9. 10.5194/bg-9-271-201
22 Londoño-Ciro, L.A., Cañón-Barriga, J.E., & J.D. Giraldo-Ocampo. 2016. Modelo de proximidad espacial para definir sitios de muestreo en redes urbanas de calidad de aire. [A Spatial Proximity Model to Define Monitoring Sites in Urban Air Quality Networks] Revista Facultad Nacional de Salud Pública 35(1): 111-122.
23 solid particles and liquid droplets between 2.5 and 10 micrometers in diameter found in the air, considered pollutants, and which can be generated by both mobile and stationary sources, either naturally or anthropogenically
24 Carriazo, F., & Gómez-Mahecha, J. A. (2018). The demand for air quality: evidence from the housing market in Bogotá, Colombia. Environment and Development Economics, 23(2), 121–138. https://doi.org/DOI: 10.1017/S1355770X18000050
25 IPBES. 2020. IPBES workshop on biodiversity and pandemics. Executive Summary
26 Burkett-Cadena, N. & Vittor, A. (2018). Deforestation and vector borne disease: forest conversion favors important mosquito vectors of human pathogens. Basic and Applied Ecology, 26, 101-110
27 Jiménez, I., Conn, J., Brochero, H. (2014). Preliminary biological studies on larvae and adult Anopheles mosquitoes (Diptera culicidae) in Miraflores, a malaria endemic locality in Guaviare department, Amazonian Colombia. Journal of Medical Entomology, 51(5), 1002-1009.
28 Montoya-Lerma, J., Solarte, Y., Giraldo Calderón, G., Quiñones, M., Ruíz-López, F., Wilkerson, R., & González, R. (2011). Malaria vector species in Colombia: a review. Memórias do Instituto Oswaldo Cruz, 106(Suppl 1), 223-238
29 Our own calculations based on Colombian epidemiological surveillance reported data published on SIVIGILA. To identify deforestation hotspots, the municipalities included in the early deforestation alerts bulletins from IDEAM were considered.

also facilitating compliance with environmental standards in export destination countries (Nicholls et al. 1998[30]; Smith & Bellotti, 1996[31]) (3.2.8).

Of the data reported in the Biodiversity Information System (SiB) Colombia, less than 2% corresponds to fungi, bacteria and archaea.

The emergence of COVID-19 in late 2019 as a major global pandemic has highlighted the link between biodiversity, global environmental change, and human health. Viruses like COVID-19 and other pathogenic microorganisms are part of biodiversity, and are hosted and transmitted by various animal species, including humans. Thus, COVID-19 is the latest in a series of diseases caused by a wild-origin virus that has emerged due to anthropogenic environmental changes that bring wildlife, livestock, and people into closer contact. Among these diseases are SARS, Ebola virus, Nipah virus, Zika virus, and influenza, reflecting a predominance of zoonotic (animal-origin) viral diseases among emerging infectious diseases that have affected people in recent decades. It is estimated that another 1.7 million currently "undiscovered" viruses exist in mammals and birds, of which up to 850,000 could have the ability to infect humans. Several scientific papers published in recent years suggest that the same environmental changes that threaten global biodiversity loss (such as land use changes like deforestation, climate change, unsustainable wildlife trade and consumption, agricultural intensification, and globalised trade) are also driving the increasing emergence, expansion, and spread of these new viral diseases (IPBES, 2020). As of July 2020, the estimated cost of the COVID-19 pandemic globally was between USD8-16 billions, with the United States alone potentially reaching USD16 billions by the fourth quarter of 2021. The cost in human lives is even more concerning. In Colombia, according to official information from the Ministry of Health and Social Protection of Colombia, as of June 27, 2021, there were 104,678 confirmed deaths from COVID-19. According to IPBES (2020), the cost of reducing risks to prevent pandemics is 100 times less than reacting to them, providing strong economic incentives for transformative change.

COVID-19 threatens biocultural diversity by affecting the knowledge, practices, and preservation of nature that are specific to indigenous and local communities. It is possible that indigenous peoples in the Colombian Amazon have been the most affected by the pandemic**.** In particular, the significantly higher risk of death in age groups over sixty represents a threat to the wiser representatives, and therefore to the transmission of indigenous and local knowledge about nature and biocultural diversity. In the first 100 days of the COVID-19 impact in Colombia, the National Indigenous Organisation of Colombia (ONIC) reported 906 confirmed cases among indigenous people from 33 out of the country's 115 existing communities, with 38 fatalities, mostly individuals over 70 years old (National Commission of Indigenous Territories, 2020[32]). In the words of the Permanent Coordination Board with Indigenous Peoples and Organizations (MPC): "The situation has led to the loss of wise individuals, historians, and advisers of our tradition. It feels as if we were witnessing the burning down and destruction of world libraries." According to the ONIC[33], as of July 13, 2020, there were 54 affected indigenous communities out of a total of 115 in the country. Additionally, it is worth noting that there are 70 indigenous communities at risk of extinction for their small size, and 39 facing physical and cultural extermination[34]; therefore, an increase in mortality due to the virus would have profound consequences on the biocultural diversity of the country[35]. According

30 Burkett-Cadena, N. & Vittor, A. (2018). Deforestation and vector borne disease: forest conversion favors important mosquito vectors of human pathogens. Basic and Applied Ecology, 26, 101-110

31 Smith, L. & A.C. Bellotti. 1996. Successful biocontrol projects with emphasis on the neotropics. http://web.entomology.cornell.edu/shelton/cornell-biocontrol-conf/talks/bellotti.html

32 National Commission on Indigenous Territories (2020). Impactos del COVID 19 en los derechos territoriales de los pueblos indígenas en Colombia. [The impact of COVID-19 on the territorial rights of Indigenous peoples in Colombia] Bogotá, Colombia: Indigenous Technical Secretary of the National Commission on Indigenous Territories.

to the Pacific Environmental Research Institute (IIAP), in the biogeographical Chocó region, home to the largest Afro-descendant and Black population in the country, and a significant number of indigenous communities, the incidence rate of the virus is higher than the national average. As per the IPBES report on biodiversity and pandemics (2020), a policy option to reduce and address pandemic risks is to value the participation and knowledge of indigenous peoples and local communities in pandemic prevention programs, aiming for greater food security and reduced consumption of wild species.

The generation of clear policies and the establishment of synergies among national authorities, research institutes, academia, social organisations, indigenous authorities, companies, and the strengthening of mechanisms to protect indigenous and local knowledge are important steps towards making knowledge and genetic heritage the basis of the country's green economy *(Well established).* The resilience of biological populations partly depends on their genetic diversity. Decreased genetic diversity negatively impacts species' ability to adapt to environments and ecosystems. However, genetic information is available for only a few species in Colombia. The gap between species awareness and knowledge of their genetic diversity is substantial. Genetic information is available for only 1% of plant species, 4% of insect species, 8% of bird species, 3% of fish species, 12% of amphibian species, 5% of reptile species, and 5% of mammal species (González-Maya et al., 2016[36]; Noreña et al., 2018[37]). This lack of information hinders the assessment of population viability and limits the sustainable use of genetic resources (2.3.3). On the other hand, there are policy proposals regarding the protection of indigenous and local knowledge that advocate for free, prior, and informed consent for access and for fair and equitable participation in the benefits derived from the use of biodiversity. These proposals have been conceived through inclusive and collaborative processes throughout the country; however, they have not been adopted (4.1.2).

Between 2014 and 2017, Colombia restored 190,000 hectares of natural ecosystems.

The loss and degradation of habitats (terrestrial, freshwater and marine) are the main direct drivers of transformation and decrease in biodiversity in Colombia *(Well established).* The drivers with the greatest impact on the transformation of different ecosystems in the country are linked to the change in land use due to the agricultural and livestock frontier expansion, the consolidation of productive enclaves such as oil palm cultivation or oil development in the case of the Eastern Plains, the development of infrastructure projects, especially roads, and urban expansion. Particularly, deforestation threatens nature's contribution to climate regulation. Furthermore, climate change is accelerating the transformation of biodiversity and the loss of nature's contributions to people throughout the national territory (5.2). Additionally, the different forms of violence in the country disproportionately affect indigenous peoples and local communities. This, in turn, directly affects their systems of knowledge, care and management of biodiversity and ecosystem services (5.4). Those affected by violence are not only humans. According to the conception of indigenous and local peoples, it also affects the "Vital Network" or "Mother Earth", which persists thanks to mutual and complex relationships between peoples and natures (4.4.4).

33 Source: https://www.onic.org.co/onic-salvando-vidas/3965-boletin-039-sistema-de-monitoreo-territorial-smt-onic-informacion-para-proteger-la-vida-y-los-territorios

34 According to the report on Colombian Indigenous peoples performed by the National Indigenous Organisation of Colombia (ONIC) and the National Centre for Historical Memory, and pursuant to their digital platform slogan "Tiempos de vida y muerte" [Times of Life and Death] https://memoria.onic.org.co/index.php

35 https://www.elespectador.com/noticias/salud/indigenas-de-la-chorrera-lanzan-llamado-de-auxilio-ante-riesgo-de-desaparecer-por-covid-19/

36 González–Maya, J. F., Arias–Alzate, A., Granados–Peña, R., Mancera–Rodríguez, N. J. Ceballos, G. (2016). Environmental determinants and spatial mismatch of mammal diversity measures in Colombia. Animal Biodiversity and Conservation, 39.1: 77–87

37 Noreña P.A., A. Gonzalez Muñoz, J. Mosquera-Rendon, et al. 2018. Colombia, an unknown genetic diversity in the era of Big Data. BMC Genomics 19(Suppl 8):859. doi:10.1186/s12864-018-5194-8

Several species of animals and plants have disappeared, others are in critical condition and others are being threatened by the degradation of ecosystems due to legal and illegal anthropogenic activities *(Well established).* Despite the seriousness of the situation, only the real loss of a very small section of some groups of animals and plants has been evaluated, without precise knowledge of the losses in ecosystems, genes and functions, information required to implement conservation measures. Strategies should focus on continuing monitoring the groups already evaluated and expanding knowledge of the threat more biological groups are facing. This could be achieved by resorting to both scientific related knowledge and traditional knowledge of the communities that inhabit the different regions of the country, in order to stop this trend.

Relatively few detailed research and technical reports are available regarding the assessment of the current state of biological diversity in the country. Most of the effort made in terms of biodiversity studies has focused on exploration related to the knowledge of new species, with many fewer efforts or studies centred on quantifying or qualifying losses. Most of the documented cases can be found in the evaluations included in the red books. In the case of the red book about terrestrial invertebrates, for example, only 0.3% of the known species were analysed and only Coleoptera, Hymenoptera, Lepidoptera and Arachnids were included, without paying attention to the rest of the taxon. For some biological groups such as Kingdom Fungi, there are not many records on the threat or loss of species and even fewer are consolidated in books or lists of species that indicate their degree of threat (2.3.2).
Although in groups such as vertebrates there is greater representation regarding the species evaluated (for example, in the red books about birds of Colombia, 17.1% of the known species have been included (Renjifo et al., 2014[38]; 2016[39]), the work carried out does not have a scheduled periodicity that allows monitoring the state and changes of this biodiversity. In the case of environmental and landscape assessments, these are mostly based on estimates of loss of forest cover, without analysing other components of the ecosystems (Chapter 2, Box 1). Finally, it is important to consider

Most of the documented cases can be found in the evaluations included in the red books.

traditional knowledge, often not included in relation to the loss of diversity. Being in the territory itself, the communities can give even early warnings about species and ecosystems that have changed or disappeared from their environment.

Monitoring for 26 years has made it possible to document changes in the presence of 153 bird species of the 235 recorded north of the city of Bogotá, through the citizen science exercise known as the "Christmas Bird Count" *(Well established).* This information has allowed us to identify the effects of local and global changes on this indicator group, birds, providing tools for their conservation. Likewise, using data on fish landings by fishermen in the upper course of the Meta River has made it possible to detect the change and disappearance of captured species and the decrease in larger sizes of animals. Promoting the monitoring of other biological groups as a conservation tool, through citizen science, will allow us to collect information to provide a quick response to environmental changes that affect species (2.4.4).

According to information from the red books about freshwater fish, between 2002 and 2017, the amount of species with some type of threat increased from 34 to 53, and the number of marine fish species went from 28 to 56. In the red books about fish in Colombia, where the status of a total of 400 freshwater and marine fish species was assessed (Mojica et al., 2012[40]; Chasqui et al., 2017[41]; Mejía and Acero, 2002[42]), habitat loss is reported as the driver of biodiversity loss for the groups that inhabit it *(Well established).*

In Colombia, it is known that 90% of continental hydrobiological resources are at the maximum level of sustainable use, and for some populations it has even been exceeded. This situation is evident in the biological

[38] Renjifo, L.M., M.F. Gómez, J. Velásquez-Tibatá, A.M. Amaya-Villarreal, G.H. Kattan, J. D. Amaya-Espinel, J. Burbano-Girón. (2014). Libro rojo de aves de Colombia, Vol. I: Bosques húmedos de los Andes y la costa Pacífica. [The Red Book of Birds of Colombia vol I: Andean and Pacific Coast Humid Forests] Ed. Pontificia Universidad Javeriana and the Alexander von Humboldt Biological Resources Research Institute. Bogotá, D.C. Colombia.

[39] Renjifo, L.M., Amaya-Villarreal, A.M., Burbano-Girón, J. and Velásquez-Tibatá, J., 2016. Libro rojo de aves de Colombia, Vol. II: Ecosistemas abiertos, secos, insulares, acuáticos continentales, marinos, tierras altas del Darién y Sierra Nevada de Santa Marta y bosques húmedos del centro, norte y oriente del país. [The Red Book of Birds from Colombia vol II: Open, Dry, Insular Ecosystems, Continental Aquatic Ecosystems, Marine Ecosystems, Highlands of Darién and Sierra Nevada de Santa Marta, and Humid Forests in the Central, Northern, and Eastern regions of the country] Ed. Pontificia Universidad Javeriana and the Alexander von Humboldt Biological Resources Research Institute. Bogotá, D.C. Colombia.

crisis of the Magdalena—Cauca, San Jorge and Sinú basins, which have reduced their fishing contributions by up to 85% (Gutiérrez, 2010[43]). The research published on fishing in the Guayuriba River (Ajiaco-Martínez et al., 2015[44]) shows how environmental deterioration was the cause of the decrease in fish populations of high commercial value, with the consequent decrease in the income of the fishermen by 50% in a period of 26 years. Of the 490 species of freshwater fish of fishing or ornamental interest reported for Colombia, 9.6% (47 species) are threatened to some degree. In consequence, while overfishing is one of the reasons for the decrease in population sizes and catch volumes, is not the main driver. Other factors, such as the habitat loss and degradation, may represent the main drivers behind these decreases (Hernández-Barrero et al., 2020[45]; Duque et al., 2020[46]) (2.2.1.2).

40 Mojica, J. I.; J. S. Usma; R. Álvarez-León and C. A. Lasso (Eds). 2012. Libro rojo de peces dulceacuícolas de Colombia 2012. [The Red Book of Freshwater Fishes of Colombia 2012] Alexander von Humboldt Biological Resources Research Institute, Natural Sciences Institute (ICN) of the National University of Colombia, WWF Colombia, and Universidad de Manizales. Bogotá, D. C., Colombia, 319 pp.

41 Chasqui V., L., A. Polanco F., A. Acero P., P.A. Mejía-Falla, A. Navia, L.A. Zapata and J.P. Caldas. (Eds.). 2017. Libro rojo de peces marinos de Colombia. [The Red Book of Marine Fishes of Colombia] Coastal and Marine Research Institute INVEMAR, Ministry of Environment and Sustainable Development. Serie de Publicaciones Generales de INVEMAR #93. Santa Marta, Colombia. 552 p.

42 Mejía, L.S. and A. Acero. (Eds.). 2002. Libro rojo de peces marinos de Colombia. [The Red Book of Marine Fishes of Colombia] INVEMAR, Natural Sciences Institute (ICN) of the National University of Colombia, Ministry of Environment. The Red Books of Threatened Species of Colombia. Bogotá, Colombia.

43 Gutiérrez F. P. 2010. Los recursos hidrobiológicos y pesqueros continentales en Colombia. [Hydrobiological and Continental Fishing Resources of Colombia] Alexander von Humboldt Biological Resources Research Institute. Bogotá. 118 pp

44 Ajiaco-Martínez, R. E., Ramírez-Gil, H., and Bolaños-Briceño, J. A. (2015). La pesquería en Bocas del Guayuriba, alto río Meta, Orinoquia colombiana. [Fishing Activity in Bocas del Guayuriba, Upper Meta River, Colombian Orinoquia Region] Villavicencio: Editorial Unillanos. 100 pp.

45 Hernández-Barrero, S., Barco, M. V., B, C. G. B., Sierra, L. S., & Stotz, W. (2020). Is Overfishing the Main or Only Factor in Fishery Resource Decline? The Case of The Magdalena River Fishery and Its Correlation with Anthropic Pressures. bioRxiv. https://doi.org/10.1101/2020.06.04.134072

46 Duque, G., Gamboa-García, D. E., Molina, A., & Cogua, P. (2020). Effect of water quality variation on fish assemblages in an anthropogenically impacted tropical estuary, Colombian Pacific. Environmental science and pollution research international. 27(1–2). https://link.springer.com/article/10.1007/s11356-020-08971-2

Key Message 2: The most important challenge for municipalities and districts is to coordinate different units of analysis, objectives, approaches and guidelines derived from territorial environmental planning instruments. At the same time, they must address the environmental determinants established to develop their territorial planning processes.

This will give greater operability to environmental planning in the country, ensuring a better management facing the degradation, transformation, fragmentation and overexploitation of nature, as well as a reduction in the loss of biological and cultural diversity and the contributions of nature.

The environmental legal and regulatory framework in Colombia is complex and sufficient. However, the lack of inter-institutional coordination and the limited levels of supervision, control and monitoring significantly increase non-compliance with environmental standards (Andrade et al., 2018[47]). Likewise, Colombia has been characterised by a prompt and adequate preparation of laws and policy proposals, in accordance with the purpose of sustainable development. Its implementation has been, nevertheless, so precarious that the development process lacks environmental sustainability or equity and is characterized by profound territorial imbalances (OECD, 2014[48], Chapter 7). In this sense, it is urgently required to develop and apply mechanisms that consolidate both the implementation and compliance of policies and regulations on environmental issues, to adequately manage the risk of loss of biodiversity and its ecosystem services caused by identified direct drivers (infographic 2).

Furthermore, the country has several opportunities. The signing of the agreement to end the armed conflict with the Revolutionary Armed Forces of Colombia (FARC) expands the possibility of carrying out effective government and protection practices regarding the different levels of biodiversity, by establishing a comprehensive institutional presence in territories where the presence of State has been deficient, among other measures. However, the poor implementation of the agreements and other aspects related to the territorial dynamics in the post-agreement imply new forms of transformation in the country's ecosystems.

47 Andrade G. I., M.E. Chaves, G. Corzo and C. Tapia (Eds.). 2018. Transiciones socioecológicas hacia la sostenibilidad. Gestión de la biodiversidad en los procesos de cambio en el territorio continental colombiano. Primera aproximación. [Socioecological Transitions Towards Sustainability. Biodiversity Management in the Processes of Change in the Colombian Mainland Territory. Preliminary Approach.] Bogotá: Alexander von Humboldt Biological Resources Research Institute. 220p.

48 OECD/ECLAC (2014). OECD Environmental Performance Reviews: Colombia 2014, OECD Publishing

To address these territorial imbalances, the Colombian environmental legislation defines the Territorial Environmental Planning (OAT) as a policy, with strategies and instruments for its development. Thus, general guidelines have been improved, such as hydrographic zoning, forest reserves zoning, natural regionalisation (which can be interpreted as zoning on a country scale, based on biophysical characteristics), among others. In turn, the National Policy for the Integral Management of Biodiversity and its Ecosystem Services (PNGIBSE) established that the OAT materialises in its socio-ecological structuring, allowing the definition of a main ecological structure (environmental determinants and other protective soils), in such a way that it constitutes the basic territorial "framework" to guarantee the conservation of biodiversity (article 2.2.1.1 Definitions, Decree 1077 of 2015[49]). The main ecological structure also allows establishing environmental management guidelines for all other types of land uses in a municipality, so that the good quantity and quality supply of ecosystem services is guaranteed by the integral management of the territory. It also supports the definition of guidelines for the management of marine and coastal areas of the country.

It is urgently required to develop and apply mechanisms that consolidate both the implementation and compliance of policies and regulations on environmental issues.

[49] Decree 1077 of 2015 (May 26), which established the single regulatory decree of housing, city, and territory.

Currently, the OAT instruments are generally created starting from an implicitly adopted unit of analysis. Thus, there are instruments such as Hydrographic Basin Planning and Management Plans (POMCA), Integrated Management Plan for Coastal Environmental Units (POMIUAC), Forest Management Plans (PGOF), among others, which zone, regulate, and, in some cases, make decisions on the use and management of the territory based on different units of analysis and through diverse scopes and approaches. However, the overlap between the several instruments in a territory, and the low operability, recognition and social legitimacy of these planning and territorial ordering resources enhance the conversion, fragmentation and overexploitation of nature, exacerbated by the dynamics of conflict and post agreement.

In this context, managing (preserving, restoring, sustainably using and generating related knowledge) the areas where social demand exceeds environmental supply is a priority, making it necessary to influence territorial planning instruments, such as the Territorial Ordering Plan (POT), Territorial Planning Schemes (EOT) or Territorial Ordering Basic Plan (PBOT), to guarantee the conservation of biodiversity, the protection of biocultural diversity and the sustainability of the provision of services on which human wellbeing depends. This also implies urgently developing and applying mechanisms that comply with environmental policies and regulations. Finally, it is advisable to consider an Instrument such as the Main Ecological Structure included in the territorial ordering instruments. With its application, not only the declared protected areas are identified in the landscape, but also areas with priorities for restoration and sustainable use, placing special emphasis on basins and their banks as key connectors in large territories.

In Colombia, most carbon stored in forests can be found in the Amazon and Andean regions.

Managing (preserving, restoring, sustainably using and generating related knowledge) the areas where social demand exceeds environmental supply is a priority.

Key findings

Changes in land use to under intensive or urbanised production systems constitute the main driver of loss of nature's contributions to society. *(Established but incomplete).* Deforestation and poor soil management result in deterioration due to erosion in 40% of the national area. Additionally, extractive activities associated with urbanisation considerably increase sediment transport and the degradation of terrestrial and aquatic ecosystems. Thus, the growth of cities has led to the direct loss of urban wetlands. For example, between 1950 and 2016, the wetlands of Bogotá lost an average of 84.52% of their extension (Cruz-Solano and Motta-Morales, 2017[50]), while Cali, during the last decades, lost more than 90% of its urban wetlands (Rosero, 2017[51]). Approaches to urban environmental management, such as sustainable cities —and more recently, the "biodivercities" initiative—, with associated indicators, can be a key guide both conceptually and regarding which data should be used to assess the state of the city considering the sustainability challenge (5.2).

Although a key criterion for decision-making and territorial planning should be based on the balance (trade-offs) of multiple uses and benefits of biodiversity and ecosystem services, studies in Colombia that simultaneously consider multiple indicators and their trade-offs in future scenarios are very limited *(Well established but incomplete).* In general, the variables considered for the analysis of models or scenarios are economic, and focused on new productive activities such as mining, oil exploitation, agriculture, infrastructure construction, and urban growth and expansion processes. Throughout the last years, from the biophysical point of view, only extreme climate variability has been considered. Most studies are limited to the use of the area of vegetation cover as an indicator or proxy variable to refer to future states of ecosystems and make inferences about their capacity to maintain the provision of ecosystem services of interest in the presence of vectors of change. However, it is relevant to delve into functional ecology studies that allow us to understand whether or not there is an adaptation of the different species and interactions to these change processes. In this context, it is recommended to proceed in studies that allow the generation or collaborative generation of scenarios to understand the drivers of change, visualise the transformation of socio-ecological systems under scenarios of change, and identify their moments of stability, resilience or vulnerability, contributing to more assertive management directions (Figure 3). It is worth noting that achieving this type of research requires institutional support and resources that guarantee continuity over time, since monitoring and instrumentation are needed both regarding the social and ecological system, to guarantee the reliability of the data used (7.3.2.1).

50 Cruz-Solano, D., and Motta-Morales, J. (2017). Estimación de la pérdida de área en los humedales de Bogotá en las últimas cinco décadas debido a la construcción y sus respectivos efectos. [Estimation of Area Loss in the Wetlands of Bogotá over the Last Five Decades due to Construction, and its Impact] Universidad Distrital Repository, retrieved from http://repository.udistrital.edu.co/handle/11349/5345

51 Rosero, J.M. (2017). Desigualdad en la conservación de los humedales urbanos en Cali: caracterización desde la economía política. [Inequality in the Conservation of Urban Wetlands in Cali: Characterisation from a Political Economy Perspective] Postgraduate thesis, Universidad del Valle, Cali, Colombia.

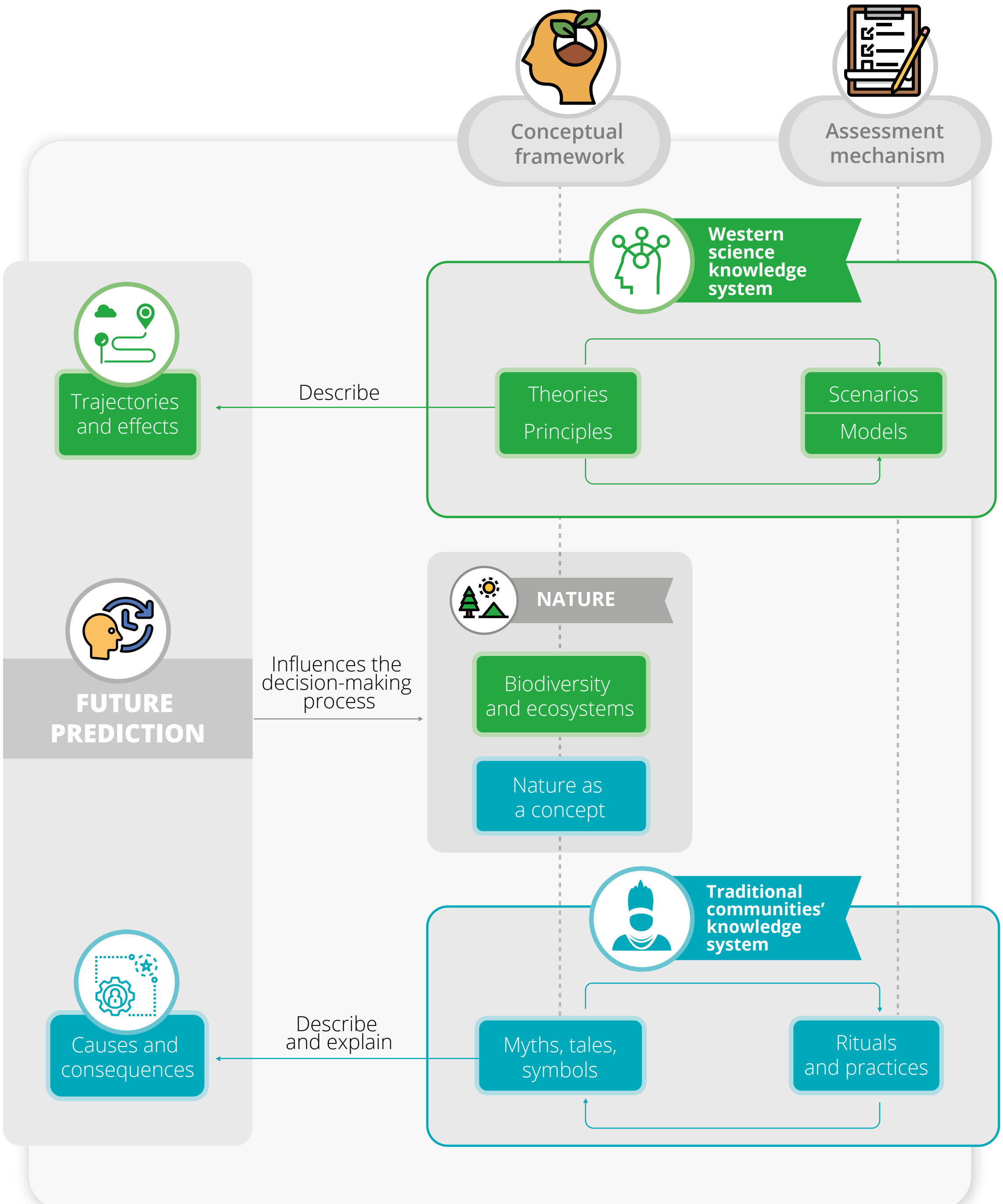


Figure 3. Diagram of decision-making evaluation mechanisms in human knowledge systems.
The colours and concepts of the generalizing (green) and context-specific (blue) perspectives proposed by Díaz et al. are used (2015)[52] for the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services framework of nature's contributions to people.

In order to change the trend of loss and degradation, it is fundamental to carry out an integral and collaborative management of nature and its contributions to the wellbeing of people This, in turn, will allow us to move towards environmentally sustainable and ecologically resilient territories. The management of sustainable territories is a result of the interaction of multiple variables, and social and natural processes. Development must be achieved considering the limits and capacities of the ecosystems that support it, to maintain the quality of life and social progress. Therefore, it is essential to achieve a "dialogue of knowledge" between the State, communities and the private sector, which allows for agreements of coexistence between diverse cultures and interests (Figure 3).

[52] Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M. A., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., ... Zlatanova, D. (2015). The IPBES Conceptual Framework - connecting nature and people. Current Opinion in Environmental Sustainability, 14, 1-16. https://doi.org/10.1016/j.cosust.2014.11.002

The generation of models and scenarios is a crucial tool for the OAT based on the dialogue of knowledge. Consequently, they should consider different policy needs and decision-making contexts at the national, regional or local level. To do this, it is necessary to directly incorporate into the models the connections between biodiversity and ecosystem services from a perspective of ecological processes, change drivers, associated socio-economic processes, policies related to land use practices, and climate change mitigation and adaptation indicators. In this way, the predictive quality of models and the availability of data would improve, as well as a more realistic understanding of the role of direct and indirect factors on biodiversity, ecosystem services and human wellbeing, and their evolution in scenarios that seek the sustainability of socio-ecological systems (7.0.5).

The form of conservation management in the country and the collective imaginary about conserving biodiversity are mainly related to the declaration and administration of protected areas ***(Established but incomplete).*** The number of protected areas in the country has increased, which has allowed progress in some of the goals set within the framework of the Convention on Biological Diversity, particularly in Aichi Biodiversity Target 11 in terms of representativeness of the national system of protected areas. However, biodiversity continues to deteriorate, restricting human populations access to and availability of ecosystem services on which their development, and even their persistence, depends on. Therefore, it is necessary to reconsider the role of protected areas and strengthen their effective articulation and complementarity with other mechanisms and instances of conservation, sustainable use and integral management present in the territory. Only then, with full "integration into the wider landscapes and seascapes", could these areas effectively contribute to the fulfilment of other aspects of Aichi Biodiversity Target 11, as well as Targets 12 (preventing the extinction of endangered species) and 13 (maintenance of genetic diversity) (7.0.5; 7.4.4).

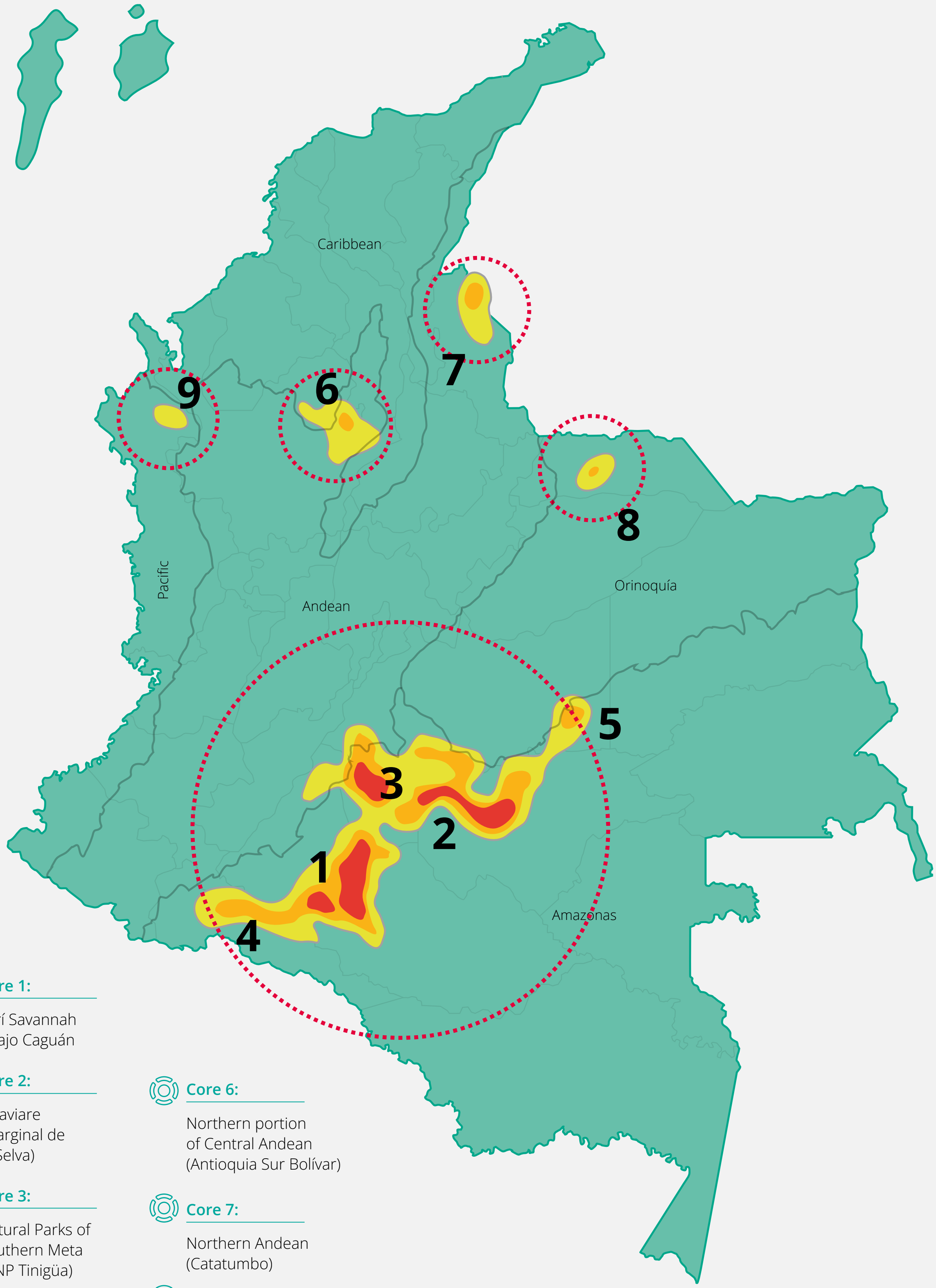
The areas of greatest forest conservation in the country largely coincide with territories where indigenous peoples, Black and Afro-descendant communities, Palenqueros, Raizales, rural and other local communities develop their own systems of government and management. This is why it is urgent to recognise and more clearly assemble knowledge and systems of community governance and environmental institutions (Well established). It is necessary to recognise bioculturality —understood as the close links between the biological and cultural diversity of indigenous peoples, blacks, Raizales, peasants and other local communities— to integrate it into the different public policies, both environmental and cultural, as well as social, political and economic, to the extent that these links can be effectively protected by means of these policies. More specifically, the agreements, regulations, protocols and strategies of the peoples for the protection and management of their territories and their biodiversity (indigenous life plans, ethno-development plans for territories of Afro-descendant, Black, Raizales and Palenqueros communities, and sustainable development plans of peasant reserve areas, as well as other local agreements for the management and care of the territory) must be recognised within the planning of territorial entities and other authorities, providing them with financing and support for their implementation, management and monitoring (4.1.1).

Areas with high contribution of above-ground biomass storage are mainly concentrated in indigenous reserves, protected areas of the National Natural Parks System, and in the Community Council of Black Communities.

Without this type of dialogue or agreement, it is likely that environmental conflicts associated with ecosystem services will continue to increase.

Colombia is one of the countries with the highest number of environmental conflicts in the world, generated mainly by mining (gold, oil, coal) and the consequent removal of biomass, which affects water channels, as well as water and food resources mainly, in the Andean, Pacific and Caribbean regions *(Well established).* If the current trend of degradation continues, together with the consequent increase in associated environmental conflicts and the repression and murder of environmental and social leaders, not only will the points of unsustainability increase, but local communities, already very vulnerable, will witness to a greater extent the loss of wellbeing generated by the impacts on ecosystem services, as they are the most dependent on nature. However, although the importance of nature in improving the quality of life of Colombians is recognised, many of its contributions have not yet been valued and there are large gaps in information regarding ecosystems in the Amazon and Orinoquía, as well as marine ecosystems and urban socio-ecological systems. Given this scenario, it is urgent to complete integral assessments considering the territorial complexity, high biodiversity, internal conflicts, social inequality, large power asymmetries and environmental conflicts. This way, it could be possible to generate agreements between the different actors to consolidate effective participation mechanisms of collective action, and for a better management of ecosystems and ecosystem services. Without this type of dialogue or agreement, it is likely that environmental conflicts associated with ecosystem services will continue to increase (3.4; 4.3).

Deforestation and the conversion and degradation of other habitats (terrestrial, freshwater and marine) are the main direct drivers of transformation and loss of biodiversity and ecosystem services in Colombia *(Well established).* Due to these direct drivers, about half of the country's ecosystems present conditions that put their permanence and provision of services to society at risk. For example, currently 15% of the paramo ecosystems are degraded at the national level. The anthropic drivers of change and degradation of this ecosystem are mainly related to livestock and agricultural activities (mainly potatoes), gold and coal mining, and to a lesser extent to construction and hunting. The highest current deforestation rate is found in the Amazon region (Figure 4). Currently, extensive livestock activities represent the main use of deforested lands, both in the humid forests of the Amazon, as well as in the Orinoquía savannah and in the paramos. It is estimated that more than 34 million hectares are used for livestock farming (with a livestock vocation of the land of only 15 million hectares), five million hectares for agricultural activities and 568,000 hectares for forest plantations (5.2.1.1; 5.2.1.6; 5.2.3.3).



Core 1:
Yarí Savannah
- Bajo Caguán

Core 2:
Guaviare
(Marginal de
la Selva)

Core 3:
Natural Parks of
Southern Meta
(NNP Tinigüa)

Core 4:
Putumayo

Core 5:
Mapiripán (Meta)

Core 6:
Northern portion
of Central Andean
(Antioquia Sur Bolívar)

Core 7:
Northern Andean
(Catatumbo)

Core 8:
Sarare (Arauca)

Core 9:
North Pacific

Figure 4. Main centres of deforestation in Colombia in 2018 (data and image credit: IDEAM, 2019) (5.2.1.1).

It is important to highlight that there are options such as sustainable and low-impact agricultural strategies that exist today in Colombia. The positive results of these strategies would allow their expansion to various ecosystems, as stated in the case of the paramo by Law 1930 of 2018[53]. Another priority ecosystem in critical danger of disappearing due to deforestation is the tropical dry forest. Only 8% (720,000 ha) of its original extension survives in the country, mostly as isolated fragments and with little representation in the system of protected areas. This can also lead to strong soil erosion and desertification, with extensive loss of the ecosystem services associated with this type of forest (González et al., 2018[54]) (5.2.1.1). Likewise, despite not being the ideal solution, the restoration of deforested lands is possible and is included in the National Restoration Plan (Minambiente, 2015[55]), as well as in several model projects between sectors and academia. Between 2014 and 2017, Colombia restored 190,000 hectares of natural ecosystems. However, with an annual deforestation rate greater than 150,000 ha in the last years, the loss and transformation of forests and other ecosystems continues to exceed their recovery (5.2.1.6). A good strategy is the inclusion of various forms of protected areas and other effective area-based conservation measures (OMEC), which together act as ecological networks. These networks can reduce and prevent deforestation, as several quantitative models indicate that deforestation tends to be lower within these networks, compared to unprotected areas of similar characteristics (Chapter 6; Box 6.8).

Likewise, analyses carried out such as the Human Spatial Footprint Index (HSFI) —which quantifies the degree of anthropic pressure by grouping factors related to the intensity of land use, the time of intervention on ecosystems and biophysical vulnerability (Etter et al., 2011[56])— identified a progressive increase in the human footprint in Colombia between 1970 and 2015. Following this trend, the gradual increase in the HSFI is expected to be also present in the year 2030. Thus, the natural areas that in 2015 had been reduced to less than half of the national territory will continue to decrease by 2030 and are expected to be reduced by a further 9%. The natural regions in which the human footprint is expected to extend over areas with low HF values by 2030 are mainly the Orinoquía and the Amazon, especially in the foothills towards the lowlands, which are currently considerably affected by deforestation and the advance of the agricultural frontier (Figure 5). In this sense, the representative ecosystems of these natural regions, such as tropical forests and flooded savannah, will continue to present similar trends concentrated in a rapid growth of human impact, despite the fact that they present the largest untransformed area compared to the others (85% and 91%, respectively). Likewise, by 2030, fragmentation is expected to increase in the North of the Colombian Andes (for example, in the Serranía de San Lucas). This would more and more "islands" with a relatively low footprint surrounded by high human impacts considerably affecting the functional connectivity between Mesoamerica and South America (Correa et al., 2018[57] and 2020[58]).

Colombia has had an annual deforestation rate of over 150,000 hectares in recent years.

[53] Law 1939 of 2018 (July 27), which established provisions for the integral management of paramo ecosystems in Colombia.
[54] González-M, R., García, H., Isaacs, P., Cuadros, H., López-Camacho, R., Rodríguez, N., ... & Idárraga-Piedrahíta, Á. (2018). Disentangling the environmental heterogeneity, floristic distinctiveness and current threats of tropical dry forests in Colombia. Environmental Research Letters, 13(4), 045007.
[55] Minambiente: Ministry of Environment and Sustainable Development. 2015. Plan Nacional de Restauración. Restauración ecológica, rehabilitación y recuperación de áreas disturbadas. [National Plan for Ecosystem Restoration: Ecological Restoration, Rehabilitation, and Reclamation of Disturbed Areas] Bogotá D.C. Colombia. 92p
[56] Etter, A., McAlpine, C. A., Seabrook, L., & Wilson, K. A. (2011). Incorporating temporality and biophysical vulnerability to quantify the human spatial footprint on ecosystems. Biological Conservation, 144(5), 1585–1594.
[57] Correa Ayram, C.A., Díaz-Timote, J., Etter, A., Ramírez, W. and G. Corzo. (2018). El cambio en la huella espacial humana como herramienta para la toma de decisiones en la gestión del territorio. [Changes in Human Spatial Footprint as a Tool for Decision-making Processes in Territory Management] In Moreno, L. A, Andrade, G. I. and Gómez, M.F. (Eds.). 2019. Biodiversidad 2018. Estado y tendencias de la biodiversidad continental de Colombia. [Status and Trends of Colombian Continental Biodiversity] Alexander von Humboldt Biological Resources Research Institute. Bogotá, D. C., Colombia.
[58] Correa Ayram, C.A., Etter, A., Díaz-Timoté, J., Buriticá, S. R., Ramírez, W., & Corzo, G. (2020). Spatiotemporal evaluation of the human footprint in Colombia: Four decades of anthropic impact in highly biodiverse ecosystems. Ecological Indicators, 117, 106630

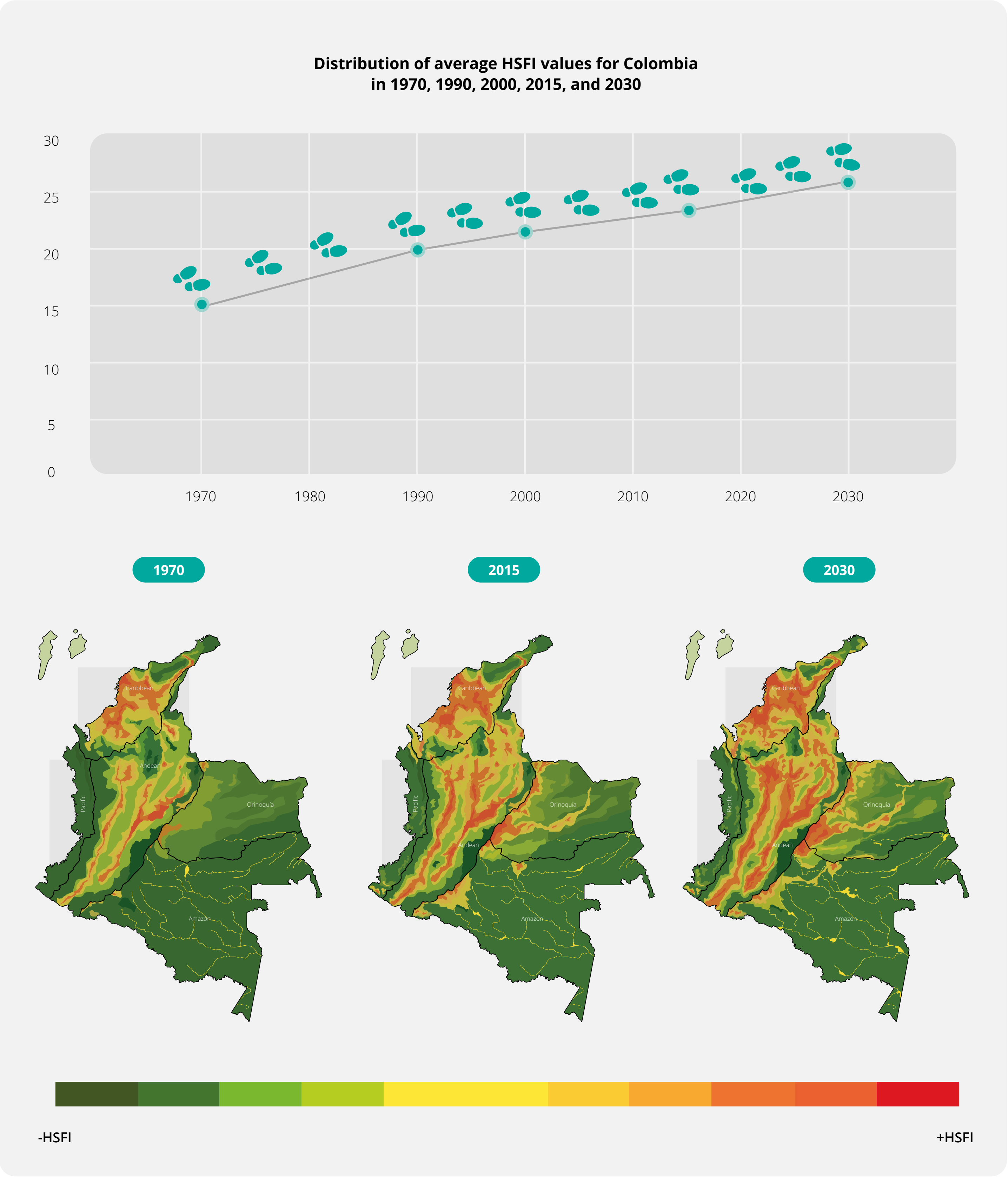


Figure 5. Scenario of the human footprint in Colombia during 1970, 2015 and 2030. Between 1970 and 2015, the average value of the human footprint increased by 50% and, by 2030, it will increase by 12%. The natural regions in which the human footprint is expected to spread by 2030 are mainly the Orinoquía and the Amazon, especially in the foothills towards the lowlands, which are currently considerably affected by deforestation and the advance of the agricultural frontier (Correa et al., 2020) (7.3.2.1; Box 7.2).

Inadequate soil management in Colombia contributes to the emission of greenhouse gases (GHG) and increases vulnerability to climate change.

The soils of Colombia are diverse, fragile, and require attention and sustainable management for the development of the countryside. Inadequate soil management in Colombia contributes to the emission of greenhouse gases (GHG) and increases vulnerability to climate change *(Well established).* More than half of Colombian soils are incipient and poorly evolved. The best agricultural soils are only equivalent to 7.5% of the national territory (Figure 6). The Andean, Caribbean and Orinoco regions are the most affected by soil degradation processes. Likewise, the area with the highest concentration of organic carbon in soil is the Andean region (more than 200 COS ton/ha), although it is a region with agricultural overload. In the Caribbean, on the contrary, the values are lower (e.g. 20 COS ton/ha), the vast majority related to inadequate land use. Urgent attention is needed in sustainable soil management. It is important to prioritise and encourage investments related to erosion and sedimentation control. The analysis carried out by Ideam and collaborators (2015) on the state of soil degradation in Colombia indicates the places and priorities that municipalities should take into account. Likewise, several institutions have been working on soil rehabilitation as a response to said degradation (3.2.2; 3.2.6; 3.2.7).

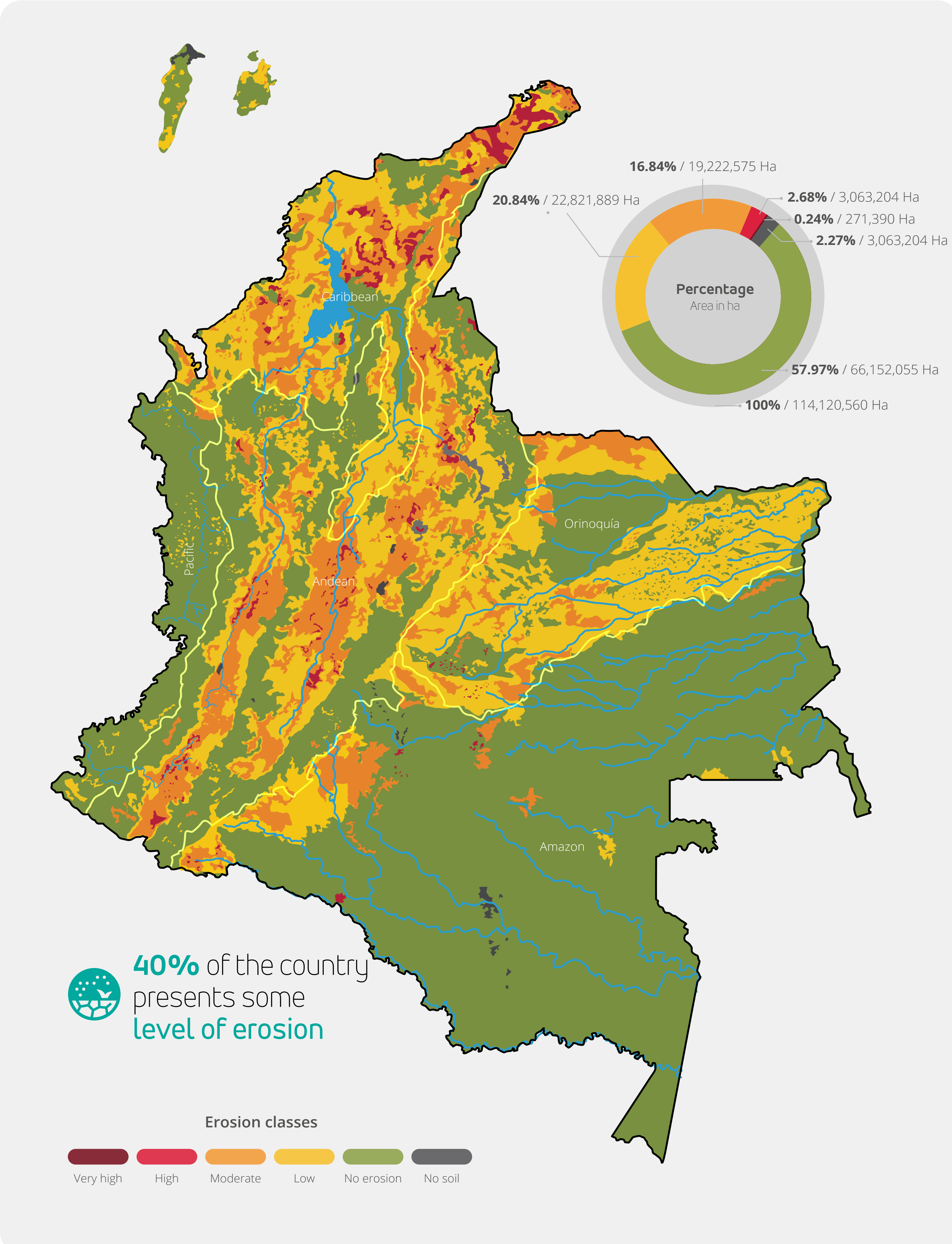


Figure 6. Zoning of soil degradation due to erosion in Colombia (Ideam, 2015), (3.2.6).

Data on the effects of climate change on precipitation and water resources for Colombia are scarce, and much data is not compiled nor accurate. However, the information available so far indicates that, by 2050, there will be an increase in precipitation in the Andean region and a reduction in the north of the country. *(Well established).* The existing information shows that rainfall in Colombia will be reduced in some areas of the country while in other areas it will be increased. The authors agree that the regions where precipitation will increase towards 2050 will be the central and northern Pacific, the Magdalena Medio, the Bogotá Savannah, Sogamoso, and the Catatumbo and Arauca valleys. On the contrary, the plains and Amazon foothills, the centre of the Orinoquía, and the central Amazon region will have a reduction in precipitation, between 10% and 15% by 2050 (IDEAM et al, 2015[59]) (7.3.5).

Sustainable water management will be a major challenge of decision-making at all levels, since the amount of water that the country will demand after 2022 will be greater than the supply and will be concentrated in the demand of the productive sectors, especially the agricultural *(Established but incomplete).* National studies show that the projected demand for water by 2022 will be 42% higher than in 2012. Domestic use will not be the sector with the highest demand, and it can even reduce its consumption by 11% if efficient water use programs are implemented. The sector that will have the greatest demand will be the agricultural sector followed by the energy sector (Figure 7) (Ideam, 2015[60]) (7.0.4; 7.3.5).

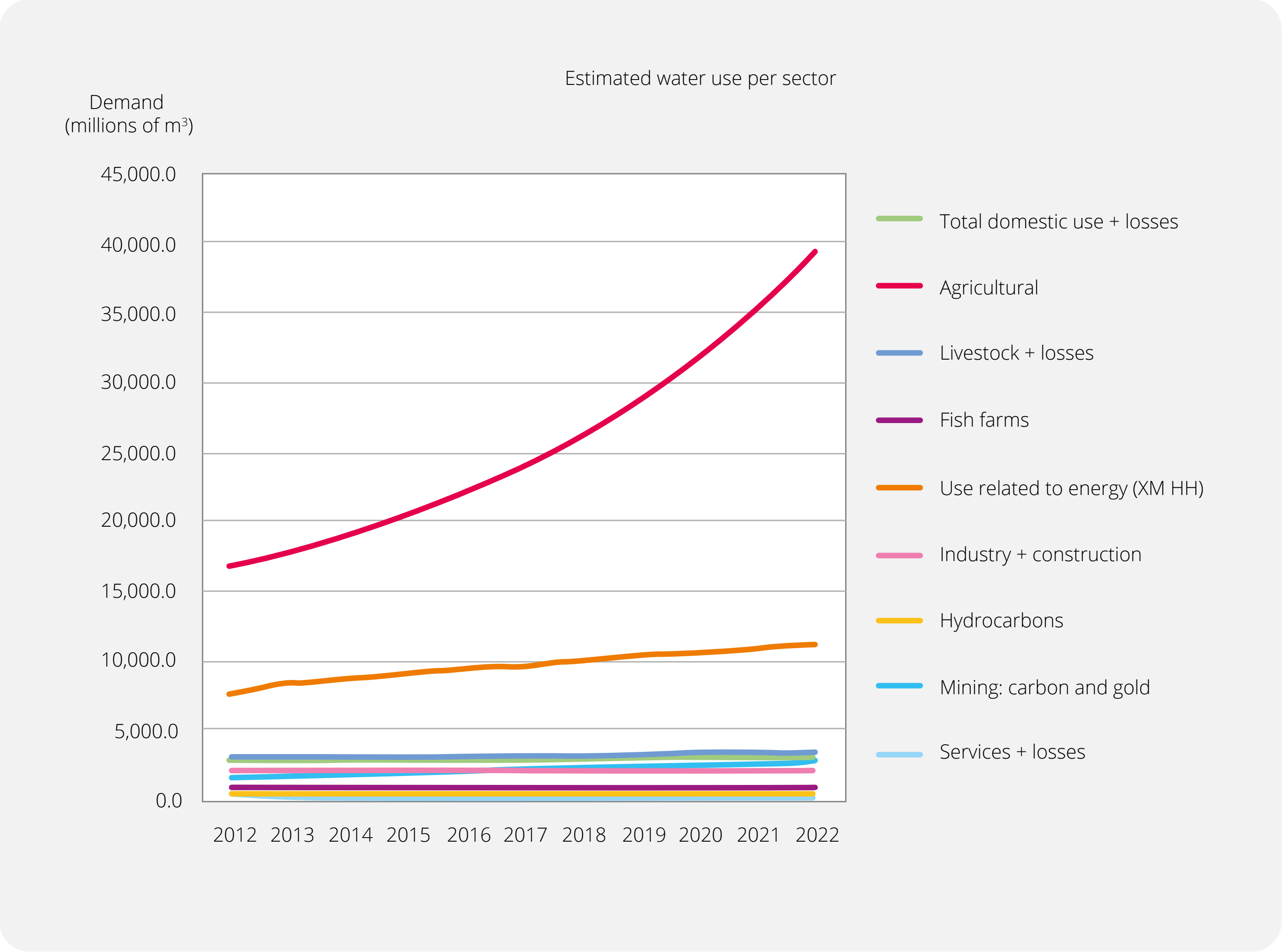


Figure 7. Water demand projections by sectors from 2012 to 2022. (Ideam, 2015).

[59] IDEAM, PNUD, MADS, DNP, Cancilleria. 2015. Nuevos escenarios de Cambio Climático para Colombia 2011 - 2100. [New Climate Change Scenarios for Colombia 2011 - 2100] Scientific Tools for Decision-making Processes - National and Regional Approach. Colombia's Third National Communication on Climate Change. Bogotá, Colombia. 59 p.

[60] Ideam. 2015. National Water Study 2014. Bogotá D.C. 496 p.

The effects of these changes will be reflected on coral reefs, mangroves and marine seagrasses through coral bleaching, species mortality and habitat loss.

The results at a global level indicate that multiple drivers of change act on marine ecosystems, and will cause a variability in the ocean close to 86% by 2050 under a "Business as usual" (BAU) scenario. Despite this, the stress of these ecosystems due to climate can be alleviated through mitigation measures, reducing their variability to 34% (*Established but incomplete*). For Colombia, the models and scenarios for change in marine and coastal ecosystems are incipient and focus on the effects of climate change on increases in temperature, sea level and CO_2 concentration, and fisheries production. The effects of these changes will be reflected on coral reefs, mangroves and marine seagrasses through coral bleaching, species mortality and habitat loss. It is therefore necessary to improve knowledge of both the impacts derived from climate change, and other drivers such as deforestation, pollution and the use of non-selective fishing gear on aquatic and marine ecosystems. This will allow progress in the conservation and sustainable management of aquatic ecosystems, as well as the establishment of reserve areas. Besides, it will enable fishing resources management exercises to maintain populations at sustainable levels for their use as proposed in the document for the Policy Strategy for the fishing and aquaculture sector (Ministry of Agriculture and Rural Development, 2019[61]) (7.3.2.3; 7.3.5).

The 2016-2100 climate change scenarios for the Colombian coastal zone, based on representative changes in emissions concentration, indicate that, by 2100, about 35.3% of corals will be exposed to sea temperatures above 28.9°C, with the corals from the archipelagos of El Rosario and San Bernardo being the most affected (Ideam et al., 2017[62]). *(Established but incomplete).* The increase in temperature trend has fewer implications for seagrasses than for corals. However, by 2100, approximately 7% of seagrass meadows would be exposed to temperatures higher than 30°C and would begin to present thermal stress (Gómez-López et al., 2014[63]). Regarding ocean acidification, global models show a possible increase for the country's marine area. However, the models in place are very general and the country lacks detailed information to measure acidification at a local scale. Therefore, it is necessary to make considerable investments in order to evaluate impacts at a more detailed scale (Ideam et al., 2017). All of the above demonstrates the need to take action in order to acquire knowledge, strengthen management and establish plans for the marine and coastal territory (7.3.2.3; 7.3.5).

[61] Ministry of Agriculture and Rural Development. 2019. Un campo para la equidad. Política agropecuaria y de desarrollo 2018 - 2022. Estrategia de política para el sector de pesca y acuicultura. [Agricultural and Development Policy 2018 - 2022. Policy Strategy for the Fisheries and Aquaculture Sector] Policy document No. 9 Bogota D.C., Colombia. 21 p.

[62] IDEAM, PNUD, Minambiente, DNP, Chancellery. 2017. Colombia's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC). Colombia's Third National Communication on Climate Change. IDEAM, PNUD, Minambiente, DNP, Chencellery, FMAM. Bogotá D.C., Colombia.

[63] Gómez-López, D.I., S.M. Navarrete-Ramírez, R. Navas-Camacho, C.M. Díaz-Sánchez, L. Muñoz-Escobar and E. Galeano. 2014. Protocolo indicador Condición Tendencia Praderas de Pastos Marinos (ICTPM). [Protocol for an Index of Condition-trend for Seagrass Meadows] Indicadores de monitoreo biológico del Subsistema de Áreas Marinas Protegidas (SAMP). [Biological Monitoring Indicators for the Marine Protected Areas Subsystem] Invemar, GEF and PNUD. Serie de Publicaciones Generales de Invemar #68, Santa Marta. 36 p.

The historical lack of planning criteria in urban growth has resulted in broad ecosystem transformations (*Well established*). Throughout the last 120 years, the country's population has grown exponentially, going from 4.1 million inhabitants in the 1905 census to 48.3 million in 2018 (DANE, 2018). The concentration of population in cities has also increased. According to the 2018 census, 77.1% of the Colombian population lives in county seats, and 7.1% lives in populated centres. Moreover, cities not only occupy the physical area in which they are located, but also require an enormous amount of extra-urban land for their normal functioning. For example, the population in Bogotá increased from 86 thousand, according to the 1907 census, to 7.2 million inhabitants according to the 2018 census, and went from occupying 326 hectares in 1900 to 42,322 urbanised hectares in 2018 (DANE, 2018). For the period 2007-2008, it required an 3,923,381 additional hectares to cover its needs for water supply, food production, energy generation, and transportation, among others (León, 2013[64]). This increase in space occupation of urban centres radically alters land use and leads to its waterproofing, fragments ecosystems and alters ambient temperature owing to heat islands that significantly increase temperature and contribute to climate change (5.2.1.5)**.**

In this context, urban planning, together with the environmental planning of the territory, is a starting point for mitigating the negative impact of the expansion of cities on local and regional biodiversity (*Established*). However, the effective impact of adequate urban planning and its implementation in the national territory is partial. Only in 21 of the 54 cities in the country whose population exceeds 100,000 inhabitants there is a consistent process established to incorporate elements of biodiversity and its ecosystem services in the planning and environmental management of the territory for the urban-regional sphere. Faced with this situation, it is important to ensure a better synergy between the central government and the municipalities, and formally include this process in all the action plans of the territorial entities (municipalities and departments), as well as in the programs of the environmental authorities corresponding to cities and regions. This will help to inform decision-making for the sustainable development of urban centres and the regions that make them viable. This effort will contribute to mitigating the negative impact of urban expansion on biodiversity when in comes to strategic ecosystems, and recognising the value of its benefits for people, especially through a comprehensive management of water resources and their regulation as an ecosystem service (6.4.5.1).

64 León, S. (2013). Indicadores de tercera generación para cuantificar la sustentabilidad urbana: ¿Avances o estancamiento? [Third Generation Indicators to Quantify Urban Sustainability. Advances or Stagnation?] EURE (Santiago), 39(118), 173-198.

Cities not only occupy the physical area in which they are located, but also require an enormous amount of extra-urban land for their normal functioning.

Key Message 3: It is essential to achieve a comprehensive knowledge about nature and its contributions to improve the integrity of ecosystems and the wellbeing of people.

In Colombia, a megadiverse, multi-ethnic and multicultural country, it is imperative to solve knowledge gaps and strengthen inter and transdisciplinary research to achieve social learning, and more legitimate and systematic decision-making process. Consequently, it will be possible to put an end to the processes of transformation and loss of biocultural diversity, as well as the dynamics with which some drivers of change transform natural capital.

In the Colombian context, the challenges faced when gaining knowledge for the decision-making processes related to biodiversity and its contributions to society can be grouped into four general points: i) strengthening systems for the characterisation, registration, comprehensive assessment and monitoring of biodiversity; ii) strengthening comprehensive research, which favours the analysis of socio-ecological dynamics and functional diversity; iii) strengthening and promoting the sharing of knowledge and its collaborative production, which recognises biocultural diversity, as well as the multiple practices and forms of knowledge and care for nature in the national territory; and iv) an articulated and timely use of the processes and results of comprehensive biodiversity research in the process of decision-making at different scales.

Despite this valuable effort, in this megadiverse country with a multiethnic and multicultural society, it is crucial to strengthen the collaborative production of knowledge.

The development of the National Environmental System and research institutes based on Law 99 of 1993, as well as the trend to strengthen research by higher education institutions, have contributed to the improvement of scientific knowledge in different disciplines. Along these lines, the consolidation of the Ministry of Science, Technology and Innovation, and the creation of groups of experts such as the "Mission of Wise Men and Women" allow us to discern a growing trend in the incorporation of scientific knowledge in decision-making processes. During the period between 2014 and 2018, an investment of a total value of COP1,151,759,000,000 and a total of 1,557 scientific research and technological development projects through different financing sources were registered. 32% of the funded projects studied medical and health sciences; 28% were related to natural sciences; 25% dealt with engineering and technology; 8% addressed social sciences, and 7% were about agricultural sciences. Despite this valuable effort, in this megadiverse country with a multiethnic and multicultural society, it is crucial to strengthen the collaborative production of knowledge, solve knowledge gaps and improve research based on the sharing of knowledge. This will allow us to achieve a more systematic social learning and decision-making process, both articulated to match the dynamics of the different territories. Consequently, it will be possible to put an end to the processes of transformation and loss of biocultural diversity, as well as the dynamics with which some drivers of change transform natural capital.

Key findings:

Colombia's investment in Science and Technology is 0.19% of the GDP, one of the lowest in the region compared to countries like Brazil (1.16%), Mexico (0.54%) or Chile (0.33%) (*Established but incomplete*). Recently, biodiversity research has been promoted by Science and Technology (S&T) programmes and strategic initiatives, such as Colombia-BIO developed by COLCIENCIAS, now the Ministry of Science, Technology and Innovation. However, investment in S&T is precarious and research results do not yet reach international standards, not even the ones corresponding to Latin America. Policymakers should reinforce support for research, taking into account the comparative advantages of the country's megadiversity and regional biocultural characteristics.

Despite the few comparative advantages, it is important to highlight that the academic offer has improved. In addition, biology, natural sciences and environmental programmes at the undergraduate level have grown since the 1970s when we only had three —currently, there are 79 programmes available throughout the country. Between the 1990s and 2000, the greatest increase occurred mainly due to the Higher Education Law of 1992 (Law 30 of 1992[65]). At the postgraduate level, we have 35 master's and 20 doctorate degrees, which reflect an increase in the relevance of research in the country. At the regional level, the Andean zone still concentrates most of the academic offer, both in undergraduate and postgraduate courses. The areas with greater diversity do not have undergraduate or graduate degrees in the topic. Regarding research groups that study biodiversity recognised by COLCIENCIAS, the number has increased from 12 in the 1980s to 382 in

[65] Law 30 of 1992 (December 28), which regulates the public service of higher education.

2015. 57% of the research groups study natural sciences, 24% address agricultural sciences and most of the groups focus their efforts in the Andean region, especially Bogotá, Medellín and Cali. In terms of quality ranking, only 13% of the groups reach category A, out of five recognised groups (Chapter 2, Boxes 2, 3, 4 and 6).

Biodiversity databases are poor in taxonomic records such as insects, fungi and microorganisms, and there is a regional imbalance in the distribution of research (*Well established*). Of the data reported in the Biodiversity Information System (SiB) Colombia, less than 2% corresponds to fungi, bacteria and archaea. Fauna represents 72% of the data, while flora depicts 26% of the total. Around 7% of the records come from the Orinoco and Caribbean regions, less than 0.5% from the insular region, and 64% come from the Andean region (SIB, 2019). Although Colombia has 220 biological collections registered in the National Registry of Biological Collections (RNC), with 27 million specimens collected, only 4.8 million (18%) are catalogued and 3.2 million (12%) are systematised. This means that 19 million (70%) are neither catalogued nor systematised. These gaps in the systematisation of biodiversity knowledge prevent us from recognising the actual impact of the degradation of ecosystems, which imply the disappearance, threat or critical state of numerous species (2.2.2; 2.2.3; 2.2.5.2; 2.2.6; 2.2.7).

Several species of animals and plants have disappeared, others are in critical condition and others are being threatened by the degradation of ecosystems due to legal and illegal anthropogenic activities (Well established). Despite the seriousness of the situation, only the real loss of a very small section of some groups of animals and plants has been evaluated, without precise knowledge of the losses in ecosystems, genes and functions, important information to implement conservation measures, sustainable use and adaptation to climate change. Relatively few detailed research and technical reports are available regarding the assessment of the current state of biological diversity in the country. Most of the efforts made in terms of biodiversity studies

has focused on exploration related to the knowledge of new species, with many fewer efforts or studies centred on quantifying or qualifying losses (2.2.2.1; 2.2.2.2; 2.2.2.3; 2.2.3; 2.2.4).

Biodiversity has traditionally been characterised in taxonomic terms as the number and abundance of species. However, the different ecological and evolutionary processes that give this biodiversity its own characteristics must be discovered and incorporated. This must be done by taking into consideration the environment where they develop, which reveals key aspects to know them, understand their contributions to wellbeing, and preserve them. These aspects have recently been addressed from the perspective of functional and phylogenetic diversity as complementary measures of biodiversity *(Established but incomplete)*. The study of functional diversity and phylogenetics are complementary approaches to the study of biodiversity. They have become essential to understand the resilience and functioning of biodiversity in the face of changing conditions and disturbances of ecological systems. Both perspectives provide information on the capacity to respond to changes and disturbances. Consequently, they are key to establish conservation priorities and sustainable use of ecosystems, biological communities, and the ecosystem services on which human communities wellbeing is based. In terms of establishing timely and assertive strategies for the management of biodiversity, it is also necessary to learn how different drivers of change can transform or affect the ecological integrity of ecosystems. In the Colombian case, an information gap is evident in the estimation of deforestation linked to illegal mining and land grabbing, for example. There is also no information related to the overexploitation of fine woods and the impact that this activity has on the populations of tree species (2.2.3; 2.2.4; 5.2.1.1).

Out of the 490 species of freshwater fish of fishing or ornamental interest reported for Colombia, 47 species are threatened to some degree.

Inappropriate production practices in the country, which constitute another driver of change in biodiversity, lead to soil degradation events (*Established but incomplete*). Although erosion is the most important degradation factor, other types of soil degradation in Colombia require investigation: the loss of organic matter and compaction caused by excessive farm work, chemical degradation due to the use of agrochemicals, salinisation due to the use of sewage for irrigation, as well as biological degradation caused by the burning of crop residues. It is necessary to estimate the magnitude of soil degradation caused by these activities. Likewise, it is important to expand the notion of sustainable management of biodiversity to include cultivated diversity and the associated knowledge systems and practices. This should also be reflected in policies, programmes and collaborative research and management projects, with adequate funding and institutional support (5.2.1.3; 5.2.2).

However, models to quantify future projections of biodiversity and ecosystem services in Colombia are generally based on the potential trends of a single change agent (*Well established but incomplete*). This does not allow us to adequately understand the spatial and temporal dynamics of the socio-ecological systems generated by the interaction of multiple agents of change. There are few studies in which multiple agents are analysed simultaneously, for example using "Integrated Assessment Models" (IAM) (see example of Calderón et al., 2016[66]). The use of this type of tools presents a huge potential to more adequately understand the dynamics of change in biodiversity and ecosystem services in Colombia. Additionally, there are very limited studies in Colombia that simultaneously consider multiple indicators and their trade-offs in future scenarios. Most make use of an indicator or proxy variable to refer to future states of ecosystems, mainly the area covered (7.3.2.1).

Almost 50% of Colombia is sea. However, the little national interest that supports and invests//that results in low support and investments in marine research has not allowed a consistent progress on efforts that effectively aim at sustainable development of the oceans, taking into account the environmental, social and economic impact that the use of its resources can generate (*Established but incomplete*). Our knowledge gap about oceans is large, despite their crucial role as a source of biological food resources, raw materials, energy resources, as a climate regulator, producer of most of the oxygen and —from a socioeconomic point of view— as a provider of wealth, development and support of economic activities for humans. In Colombia, knowledge of marine biodiversity has been focalised in shallow systems. In contrast, explorations in deep-sea areas, despite their recent advances, are not able to solve our greatest gaps in knowledge, due to their high costs and requirements for advanced technology. Another gap detected is the lack of taxonomic expertise for the study of several minor groups. Additionally, there is a poor assessment of the contributions to the wellbeing provided by this type of ecosystems. Specifically, it is important to research scenarios of change over time in marine and terrestrial socio-ecological systems. Knowledge about dynamics, attributes, properties and interactions between both social and ecological systems

66 Calderón, S, Alvarez A.C, Loboguerrero A.M, Arango S, Calvin K, Kober T, Daenzer K and Fisher-Vanden K. 2016. Achieving CO2 reductions in Colombia: Effects of carbon taxes and abatement targets. Energy Economics (56): 575–586. https://doi.org/10.1016/j.eneco.2015.05.010

is required to support territorial planning exercises and evaluate the possible effects of conservation instruments (2.2.1.8; 2.2.1.9; 2.2.2.10; 2.2 .6.1; 2.2.6.3).

The lack of detailed information and the informality of most fishing in Colombia poses a challenge for the sustainable management of fishing and aquaculture resources (*Established but incomplete*). This lack of information on the state of fisheries prevents a clear diagnosis of the effects of overfishing and non-selective fishing on the state of marine and freshwater ecosystems and their resources. Furthermore, aquaculture facilities can be a vector for pathogens and affect natural populations (O'Shea et al., 2019[67]). However, in Colombia we are unaware of how they affect wild populations of aquatic organisms, mainly due to lack of knowledge of local biodiversity and the lack of institutional capacities in the country (5.2.6.2).

There is little participation of indigenous peoples and local communities in research as part of the science, technology and innovation system of universities, SINA research institutes and Colciencias, which should be performed through consensual programs that promote the training, participation and decision-making capacity of communities in the documentation, dissemination and transmission of this knowledge. Nevertheless, it is necessary for the design and development of conservation and sustainable use strategies (*Established but incomplete*). This need is especially evident around Afro-descendant, Black, Raizal, Palenquera and Rom populations that are underrepresented in academic literature, as well as the Pacific and Orinoco regions, and notably in the insular Caribbean (archipelago of San Andrés, Providencia and Santa Catalina). Additionally, the knowledge systems of urban inhabitants about nature are practically imperceptible, despite the fact that the majority of the Colombian population lives in cities. Studies on indigenous and local knowledge on climate change are also scarce, as well as their combination with regional and national adaptation measures, despite the fact that such articulation has been widely recommended and could significantly contribute to the situation (5.2; 5.5).

It is impossible to differentiate the impact of this phenomenon on rural populations, given the non-existence of this category in official demographic data. However, according to the National Survey on Quality of Life (DANE, 2019), 34.4% of Colombian households identify themselves as rural, and their multidimensional poverty index is 29%, more than ten points above the national total. Besides, 27% do not have access to improved water sources, which places this group at high levels of vulnerability. According to an analysis carried out in April 2020 by researcher Carlos Duarte based on data from the national agricultural census, "more than 33% of the producers residing in the dispersed rural area registered are between 40 and 54 years old. Specifically, a higher proportion of male residents compared to female residents is observed, also more visible in the ages between 40 and 54 years. That is, it is an older population at risk in the face of the pandemic"[68].

Medicine is one of the areas where the existence and practice of knowledge of the INAPRRCL[69] communities is clearly observed. At present, when the state health infrastructure is hardly reaching the communities, these practices play a key role and are strengthened. Traditional medicine is frequently mentioned as a key resource in the strategies of local organisations, where the health of the territory is understood as closely linked to the collective and individual human health, and the caring and healing of both is intertwined[70,71]. In INAPRRCL communities, community medicine[72] becomes a strategy for recovery and strengthening in situations such as the COVID-19 pandemic. It is how diseases that affect the wellbeing of the person or the community are faced.

67 O'Shea, T., Jones, R., Markham, A., Norell, E., Scott, J., Theuerkauf, S., and T. Waters. (2019). Towards a Blue Revolution: Catalysing Private Investment in Sustainable Aquaculture Production Systems. The Nature Conservancy and Encourage Capital, Arlington, USA.

68 Source: https://lasillavacia.com/silla-llena/red-rural/radiografia-rural-de-cara-la-pandemia-72306

69 Indigenous peoples and communities, Black and Afro-descendant communities, Palenqueros, Raizales, Rom, rural and other local communities.

70 For example, statement from the Indigenous peoples from south of the Amazon: https://www.gaiaamazonas.org/uploads/uploads/final20200425comunicadocovidamazonas.pdf

71 https://www.cric-colombia.org/portal/tejer-la-palabra-para-desamarrar-la-movilizacion-ciudadana-en-tiempos-de-pandemia/ https://www.filac.org/wp/comunicacion/actualidad-indigena/la-medicina-tradicional-con-la-que-pueblos-indigenas-de-colombia-hacen-frente-al-covid-19/

72 Amaris-Álvarez, A.F., Díaz-Rueda D. M., Chautá- Paéz, C. A. and Nemogá-Soto G. R.. (2020). Las plantas medicinales como eje revitalizador de la memoria biocultural: el caso de la comunidad muisca de Sesquilé (Cundinamarca, Colombia). [Revitalizing Biocultural Memory thorugh Medicinal Plants as: the Muisca Community of Sesquilé (Cundinamarca, Colombia)] (Peer review, July 2020)

Key Message 4: To eradicate the dynamics of loss and degradation of biodiversity and ecosystem services, –in addition to carrying out comprehensive and nature management– it is crucial to promote transformative changes based on the sharing of knowledge, which generates transformative knowledge and quality information for effective decision-making processes.

It is necessary to assess transformation trends and incorporate the results in the development of prospective models for the construction of future scenarios. These models must incorporate, among others, the growing urban and social value of biodiversity, and the internalisation of environmental costs in production processes, which can be used to reach collective decisions in order to move towards sustainable territories. It is also necessary to improve social learning through the systematisation of results of innovative strategies for the preservation, restoration, sustainable use, and generation of knowledge in rural, urban and mixed territories. As a consequence, it will be possible to replicate them in this transition to socio-environmentally resilient territories and in favour of the wellbeing of all Colombians.

Environmental management has become deteriorated in the last twenty years due to the two predominant types of enrichment illegal and easy enrichment.

The recent assessment of progress towards the Aichi Targets of the Strategic Plan for Biodiversity (2011–2020) adopted by the Convention on Biological Diversity (CBD) revealed that, despite the efforts of countries to address the causes of biodiversity loss, most of the goals were not achieved. One of the conclusions of the assessment is that, in order to build the vision set for 2050 —biodiversity is valued, maintained, restored and used rationally, maintaining ecosystem services, sustaining a healthy planet and providing essential benefits for all—, "a much higher level of ambition" is required. To this end, three lines of action are suggested that countries must put into practice to achieve the objectives of the CBD and this global vision based on the new Global Framework for Biodiversity after 2020:

- Governments shall increase national efforts to implement the new post-2020 Global Biodiversity Framework, providing the necessary resources and strengthening an fruitful environment, such as enabling conditions.
- Countries shall foster the integration of biodiversity into decision-making processes. It is assumed that pressures on biological diversity and ecosystem services can only be reduced if biological diversity is explicitly included in government policies and in all economic sectors.
- There are positive experiences that indicate how to address the challenges posed by supporting sustainable development, when minimising the impact of climate change, and reversing the loss of biological diversity. "It points out the different transitions that need to be promoted in all aspects of the relation between people and nature. There are some incipient examples that demonstrate that these transitions are already occurring in different parts of the world, but it is necessary to expand them, strengthen them, and encourage them" (CBD Secretariat, 2020[73]).

In 2018, the Humboldt Institute proposed socio-ecological transitions towards sustainability (TSS), such as "biodiversity management processes that are appropriated and negotiated by social actors in order to modify the undesired change in the ecological and social system to lead it through concerted actions, towards a state that enhances the wellbeing of the population and the environmental security of the territory" (Andrade et al., 2018). The TSS are the Colombian proposal in response to the transformational changes established by the CBD and the IPBES as necessary to advance in the fulfilment of the aforementioned 2050 vision, and which are currently established as a key resource in the agreement of the Post-2020 Global Biodiversity Framework.

Although Colombia poses innovative positions in the international arena, it still has to face and solve enormous and pressing challenges so that consistent progress can be made in these socio-ecological transitions towards sustainability. On the one hand, the trend of loss and degradation of biodiversity and ecosystem services (BES) in Colombia is well established, and the impacts in social, cultural and economic terms, and on the natural heritage and wellbeing of the country are enormous. For instance, based only on the economic impact, if deforestation continues to increase, by 2030 Colombia could lose around COP1.5 trillion of Gross Domestic Product (GDP) and between COP1,034 and COP1,670 million in genuine savings, considering that, according to IDB estimates, in 2014 there were 58.8 million hectares of forest, while in 2030 there may be only 48.8 million hectares. On the other hand, according to Julio Carrizosa Umaña, one of the most prominent environmentalists in our country, environmental management has become deteriorated in the last twenty years due to the two predominant types of enrichment: illegal and easy enrichment. The first still affects a wide variety of areas, from the control of deforestation to "the normal functioning of entire corporations." In 2015, the author stated that this was the main and direct factor in environmental deterioration in the regions affected by illegal mining and deforestation to establish crops for illicit use. Currently, the illicit extraction of forest resources and land grabbing can be added to this list, in addition to the increase in the illicit extraction of minerals and illicit crops.

Through citizen science, changes in the presence of 153 bird species out of the 235 recorded north of Bogotá city have been documented over 26 years.

[73] Secretariat of the Convention on Biological Diversity (2020) The Global Biodiversity Outlook 5 (GBO-5). Montreal.

The second predominant type, easy enrichment, is the main underlying cause of environmental conflicts between "economic projects leading to the use of natural capital to obtain quick and high returns and those in charge of enforcing the regulations that protect ecological heritage." (Julio Carrizosa Umaña in Guhl Nannetti and Leyva, 2015[74]). Building, coordinating and carrying out socio-ecological transitions towards sustainability, as a national goal, must begin by analysing past decisions, given that "war and drug trafficking constitute an essential explanatory context, without which it is difficult to understand the real experience of Colombian environmental management" (Julio Carrizosa Umaña in Guhl Nannetti and Leyva, 2015).

Looking forward, both the country and the planet must carry out a multi-paradigm transition towards a more harmonious relationship with nature. To make sustainability viable, this transition must be supported by national, regional and local governments, the markets of goods and services, and academia. Although paradigm transitions usually occur in intergenerational terms, the speed of loss of biodiversity and contributions to the wellbeing of societies forces the accelerated development of transformational changes in the management of territories. These changes shall have an impact on the behaviour of individuals, as constituents of the market, in the sectors, unions and companies that produce goods and services; in the academy that studies, systematises and generates models and scenarios of desirable futures, and in the different forms of government of the territories, in their role as regulatory bodies of the market economy transactions.

In this sense, implementing socio-ecological transitions towards sustainability (TSS) is no longer an option but an urge. Firstly, TSS involve accepting change, not only in the context of ecosystem dynamics, but also in terms of social transformations in the territory, under the socio-ecosystem approach (Andrade et al., 2018). Secondly, uncertainty must be assumed, not only from the relative lack of knowledge regarding Colombian biodiversity, but also from the little information and knowledge about the functional relationships between natural systems, productive systems, and the abiotic environment in which they develop. Uncertainty is also evident in the low predictive capacity for climatic variables, due to the relation between biodiversity, climate and drivers of transformation in the territory, which defines a strong dependency between the desired transition and the assessed territory.

Key findings

The suggestions and key messages included here constitute only initial steps that, based on an analysis of the past, allow progress in this transition to socio-environmentally resilient territories which favour the wellbeing of all Colombians.

The regional assessment of biodiversity and ecosystem services (BES) for the Americas indicates a decline in the conditions of biodiversity and ecosystems, and a consequent reduction in nature's contributions to quality of life (*Well established*). This downward trend of BES in the case of Latin America is influenced by an increase in population, the prevailing logic of economic growth, consumption patterns, inequality and weak government systems. In the future, under a "Business as usual" (BAU) scenario towards 2050 and through the GLOBIO model, an increase in unsustainable land use is expected due to agricultural practices and increases in temperature, changes in precipitation regimes and extreme climate events. This, in turn, is a consequence of climate change with its immediate consequences on the loss of biodiversity (IPBES, 2018). For Colombia, the future projections of biodiversity under the BAU scenarios maintain the same trends as IPBES-America. Changing trends is a regional and national imperative, in which international commodity markets also intervene, through the translocation of raw materials. Transformational changes, pursued by both the Convention on Biological

[74] Guhl Nannetti, E. and P. Leyva. 2015. La gestión ambiental en Colombia, 1994-2014: ¿un esfuerzo insostenible? [Environmental Management in Colombia, 1994-2014: Is it an Unsustainable Effort?] FESCOL, Foro Nacional Ambiental Quinaxi. Bogota D.C. 224 p.

Protected areas are essential to maintain the material and non-material contributions of nature for present and future generations throughout the Colombian territory.

Diversity, the IPBES and IPCC platforms, and the links between them, are the path to planetary sustainability (7.3.2; 7.5.1).

The trend of loss and degradation of biodiversity and ecosystem services (BES) in Colombia is well established (*Well established*). Although Colombian environmental regulations are one of the most advanced in the region, and the National Policy for the Integral Management of Biodiversity and its Ecosystem Services (PNGIBSE, Minambiente, 2012) has been collaboratively developed and considers innovative aspects (such as inter-sectoral, trans-sectoral environmental management and risk management), the erosion of biodiversity and its ecosystem services maintain negative trends. Furthermore, the current COVID-19 pandemic teaches society two prevailing lessons, costly in human lives and even more so in terms of employment, productivity and economy: 1) changes are possible, inertia can be broken by supreme values of society; and, 2) transformative changes are less costly when they are established and developed from prevention, than when they are executed in response to emergencies.

The different forms of violence in the country disproportionately affect indigenous peoples, local communities and social leaders who defend the territory and the environment. This directly affects their knowledge systems and practices, and thus the biodiversity and ecosystem services of the country (*Well established*). According to the Unit for Comprehensive Attention and Reparation to Victims (2020, created by Law 1448 of 2011), the number of people recognised as victims and included in the Single Registry of Victims (RUV) is nearly nine million[75], which correspond almost entirely to people who live in rural areas. About 17% (1,520,299 people) belong to indigenous and local peoples and communities. The Truth Commission considers that 92 out of the country's 104 indigenous peoples have been victims of the conflict. It highlights that, according to the Single Registry of Victims (RUV), an indigenous boy or girl is 674 times more likely to be a victim or recruited and used by an illegal armed group than any other child in the entire country. According to the report on indigenous peoples in Colombia, carried out by the National Indigenous Organisation of Colombia (ONIC) and the National Centre for Historical Memory, 70% of these peoples are in danger of extinction. Colombia is the Latin American country with the most murdered social leaders, defenders of human rights, territory and the environment, and one of the leading countries in this regard at the global level for the period 2016-June 2019, according to UN figures (2019) (4.4).

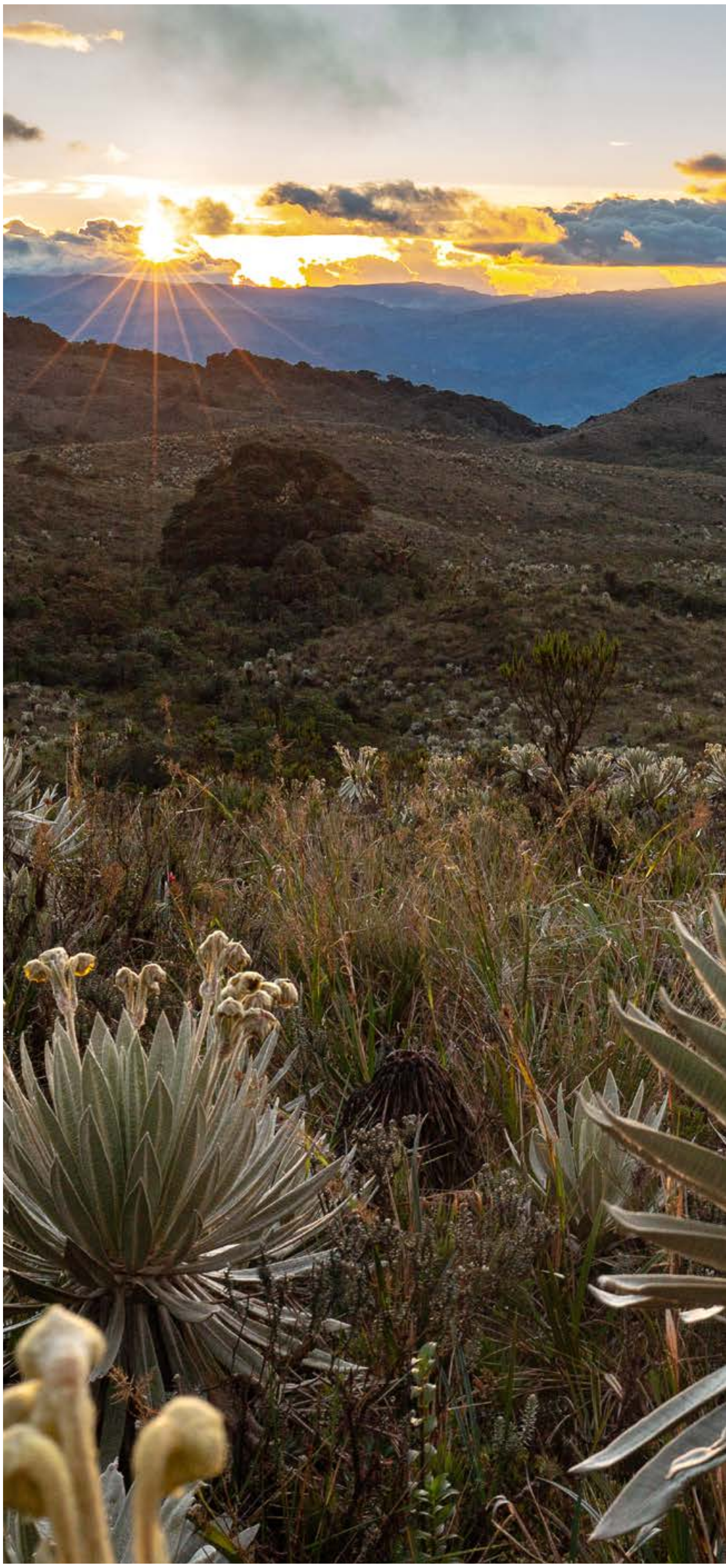
Protected areas are essential to maintain the material and non-material contributions of nature for present and future generations throughout the Colombian territory (*Well established*). These contributions, however, are in decline. Deforestation in protected areas increased by 70% in 2018 compared to the previous year, despite the fact that it decreased by 10% throughout the national territory. Deforestation in protected areas affects carbon capture and sequestration. In 2018, an average of 2.5 hectares were deforested in the Systems of National Natural Parks (SPNN) per hour. The most affected area by deforestation was the Tinigua National Natural Park, that presented an increase of 218.7% in one year, going from 3,285 hectares deforested in 2017 to 10,470.41 in 2018. It is necessary to improve incentives for the conservation of forests and strategic ecosystems with programmes that reduce pressures on protected areas, and also provide sustainable productive alternatives that allow communities to obtain income, as well as preventing the expansion of the agricultural frontier and supporting the establishment of ecological networks (Chapter 3, Box 3.5; 3.2.2; 3.2.4; 3.2.5).

75 8,953,040 according to the UARIV official website, consulted in March 2020: https://www.unidadvictimas.gov.co/es/registro-unico-de-victimas-ruv/37394

To change the trend of loss and degradation of biodiversity, it is fundamental to carry out an integral and collaborative management of nature and its contributions to the wellbeing of people. This, in turn, will allow us to move towards environmentally sustainable and ecologically resilient territories. Sustainable territorial systems are based on the principle that the necessary condition for an activity to be sustainable is that the territory where it is located is also sustainable (Guhl, 2018). The management of sustainable territories is a result of the interaction of multiple variables, and social and natural processes. Development must be achieved considering the limits and capacities of the ecosystems that support it, to maintain the quality of life and wellbeing. Therefore, it is essential to achieve a "dialogue of knowledge" between the State, communities, academy, science and the private sector, which allows for agreements between diverse cultures and interests. In addition to these biophysical changes, in a context like the Colombian one, sociocultural paradigms are constantly evolving. This dynamic has not been explicitly and clearly incorporated in the generation of scenarios and models, which are essential to establish the future BES trends it supports (*Established but incomplete*).

Even more, the development of scenarios involving other forms of knowledge in Colombia has allowed the sharing of experiences and knowledge between different actors. The objective is to explore the institutional mechanisms that underlie decision-making processes and that can be thought of as exercises aimed at increasing the resilience of biophysical systems and adaptive management mechanisms of environmental governance towards possible future changes in the socio-ecological interaction of rural communities. Through its application, participants have achieved a better understanding of the socio-environmental problems of the territory, promoting the collaborative learning process between local and technical-scientific knowledge, and supporting the territorial planning processes. Despite the advantages and positive applications towards sustainable resource management, this type of collaborative approaches and methods in Colombia is still very limited (*Established but incomplete*, 7.2.2 and 7.4.1). **The challenge is to adopt sustainable environmental policies, regulatory frameworks and new incentives to balance land use and the conservation of biodiversity and ecosystem services** (Established but incomplete; 7.4.2).

In marine-coastal environments, the need for a social approach to restoration is emphasised, taking into account that these ecosystems are socially and ecologically complex (Invemar, 2018[76]). In order to achieve



[76] INVEMAR, 2018. Informe del estado de los ambientes y recursos marinos y costeros en Colombia, 2017. [Report on the Condition of Marine and Coastal Environments and Resources in Colombia, 2017.] Serie de Publicaciones Periódicas #3. Santa Marta. 180 p.

this goal, work must be done on mechanisms that allow the effective intervention of different policymakers. This is why it is necessary to strengthen and develop conceptual and practical governance and management models that favour restoration actions (Minambiente et al., 2019).

The legal and regulatory framework in Colombia is complex and sufficient. However, the lack of inter-institutional coordination and the limited levels of supervision, control and monitoring significantly increase non-compliance with environmental standards. In the period between 2010 and 2018, the country improved in legislative aspects and in the development of plans and policies, but made little progress in actions with an actual impact. Colombia has been characterised by a prompt and adequate preparation of laws and policy proposals, pursuant to the purpose of sustainable development. However, its implementation has been so precarious that the development process in Colombia lacks environmental sustainability and equity, and is characterised by deep territorial imbalances (OECD, 2018[77]) (6.1; 6.2).

The implementation of updating and training programs for government officials who develop policies and regulations is a priority, as well as for authorities in the environmental sector and control agencies. These programmes should address the conceptualisation and establishment of procedures for the comprehensive management of biodiversity and its ecosystem services, as well as the protection of biocultural diversity. The country has institutional capacity, not only in environmental institutions, but also in those related to the management of sustainable territories and local development. However, it is necessary to strengthen technical capacities to identify and differentiate the particular needs of each territory, to facilitate influential participation and, especially, to develop appropriate methodologies and contemplate precise budgeting for the implementation of monitoring, assessment and accountability actions (6.2; 6.6).

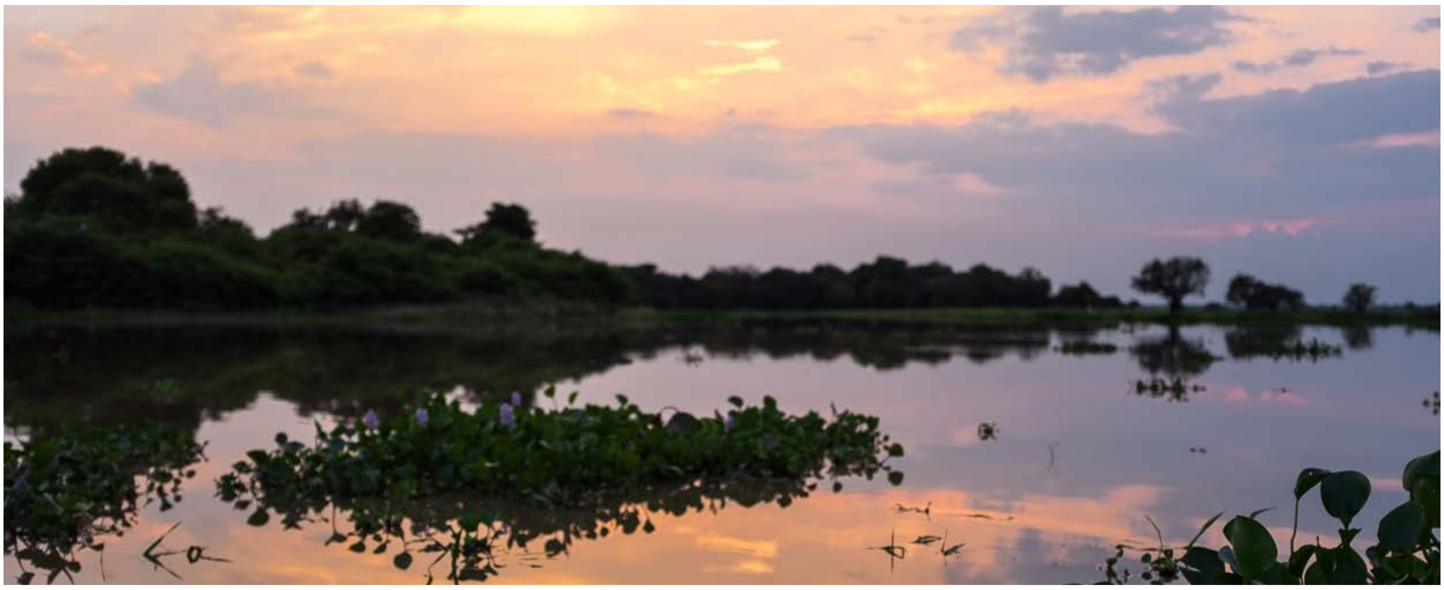
Improving biodiversity governance systems implies that civil society should organise itself better, defend and make better use of existing spaces for participation, demand that institutions properly fulfil their mission and function, and demand adequate and transparent management of available financial resources. The greatest challenge for better environmental management is not changing legislation or institutional organisation. Rather, it is being able to make a better use of these tools and manage the application of legislation to a greater extent, as well as the available

[77] OECD (2018). "Biodiversity conservation and sustainable use in Latin America. Evidence from Environmental Performance Reviews." ENV/EPOC/WPEP (2018)8/REV1. 92 pp. Currently under edition. https://read.oecd-ilibrary.org/environment/biodiversity-conservation-and-sustainable-use-in-latin-america_9789264309630-en#page1

institutions, thus demanding a better management by existing institutions according to their goals. In order to achieve this, civil society must continue to strengthen itself to demand and monitor institutional actions (6.6.2; 6.6.4).

The loss and degradation of habitats (terrestrial, freshwater and marine) are the main direct drivers of transformation and decrease in biodiversity in Colombia (*Well established*). These drivers have affected between 80% and 100% of the ecosystems considered vulnerable, in danger or in critical condition in the country. The dry forest in Colombia, for example, maintains remains of no more than 10% of its original extension, mostly as isolated fragments and with little representation and connectivity in the protected area system (García et al, 2014[78]; Etter et al., 2017[79]; Corzo et al., 2021[80]). Additionally, the precipitation projections, according to the average greenhouse gas emission scenario in Colombia's Third National Communication for the Intergovernmental Panel on Climate Change (Ideam et al., 2017), show a decrease on the Caribbean coast and an increase in the interandean valleys, with the subsequent loss of competitiveness of these ecosystems in the face of the sub xerophytic shrublands in the Caribbean and with the humid forests in the interandean valleys (Magdalena, Cauca and Patía). Consequently, conserving dry forest ecosystems and associated ecosystem services no longer depends exclusively on the declaration of public protected areas and the designation of private protected areas, but on a design of interconnected landscapes that ensure ecological functionality, even in transformed territories. Therefore, it is urgently required that mandatory environmental investments associated with environmental compensations join their efforts with market regulation mechanisms (i.e. the Roundtable on Sustainable Palm Oil, RSPO) and integrative government initiatives 5.2.1.1; 5.2.1.6; 5.2.3.3.

The loss and degradation of wetlands has increased the vulnerability of lower-income people to flooding (*Well established*). In Colombia, the most frequent event that affect the largest number of people is flooding (Aguilar et al., 2008[81]). As already mentioned, around 24% of the country's areas with wetland characteristics have been transformed (Jaramillo et al., 2015 and 2016). It is estimated that around 50% of the transformed wetland areas is associated with extensive livestock farming (Ricaurte et. al, 2017[82], Jaramillo et al., 2015[83] and 2016[84]) (3.2.4; 3.2.7).



Around 24% of the country's wetlands have been transformed.

78 García, H., Corzo G., Isaacs P. and Etter A. (2014). Distribución y estado actual de los remanentes del bioma de bosque seco tropical en Colombia: insumos para su gestión Bosque seco tropical en Colombia [Distribution and Current Status of Remains of the Tropical Dry Forest Ecosystem in Colombia: Resources for its Management] (ed. C Pizano and H García) (Bogotá: Alexander von Humboldt Biological Resources Research Institute) 229–51 pp.

79 Etter, A., Andrade, A., Saavedra, K., & Cortés, J. (2017). Actualización de la Lista Roja de los Ecosistemas Terrestres de Colombia: conocimiento del riesgo de ecosistemas como herramienta para la gestión. [Update of the Red List of Terrestrial Ecosystems of Colombia: Understanding ecosystem risk as management tool] Biodiversidad.

80 Corzo, G., L.S. Castillo, C. Correa, S. Vargas, N. Corral-Gómez. Chapter under review (2021) El rol de las áreas protegidas en la conservación del bosque seco [The Role of Protected Areas in the Conservation of Dry Forests]. In: 2021. Norden N., R.Gonzales and C.Pizano (Ed), Bosques secos de Colombia Vol 2. [The Tropical Dry Forest in Colombia vol II] Humboldt Institute. Bogotá, Colombia.

81 Aguilar, A., Bedoya, G., Hermelin, M. (2008). Inventario de los desastres de origen natural en Colombia, 1970-2006-: limitantes, tendencias y necesidades futuras. [Inventory of Natural Disasters in Colombia, 1970-2006 - Limitations, Trends and Future Needs] Gestión y Ambiente, 11(1)

82 Ricaurte, L., Olaya-Rodriguez, M., Cepeda-Valencia, J., Lara, D., Arroyave-Suárez, J., Finlayson, C., Palomo, I., (2017). Future impacts of drivers of change on wetland ecosystem services in Colombia. Global Environmental Change. 44, 158-169

83 Jaramillo, U., Cortés-Duque, J. and Flórez, C (2015). Colombia Anfibia. Un país de humedales. [Amphibian Colombia. A Country of Wetlands.] Volume I. Bogotá, D.C., Alexander von Humboldt Biological Resources Research Institute. II: 140 pp.

84 Jaramillo, U., Cortés-Duque, J. and Flórez, C (2016). Colombia Anfibia. Un país de humedales. [Amphibian Colombia. A Country of Wetlands.] Volume 2. Bogotá, D.C., Alexander von Humboldt Biological Resources Research Institute. II: 116 pp.

Degradation by erosion is the most important type of soil degradation in the country (Well established). 40% of the continental surface presents some degree of soil degradation due to erosion, with a total of 34 erosion sources throughout the country: 16 focal points in the Magdalena–Cauca hydrographic area, eight in the Caribbean, four in the Amazon, three in the Orinoco and two in the Pacific, and an incipient but important focal point of erosion on the island of Providencia (Ideam et al. al., 2015). The activities that present the highest proportion of area affected by erosion are, in increasing order, irrigation districts associated with areas of commercial agriculture with high production, the agricultural sector, agricultural use defined by mosaics of crops and pastures, and livestock (Figure 8). Although the latter is not the main practice that degrades the soil, due to its large area, the largest number of hectares affected by erosion in the country are under livestock use. It is important to highlight that although erosion is the most important soil degradation factor, other types of soil degradation in Colombia require attention, such as the loss of organic matter and compaction caused by excessive farm work, chemical degradation due to the use of agrochemicals, salinisation due to the use of sewage irrigation, as well as biological degradation caused by the burning of crop residues. It is necessary to estimate the magnitude of soil degradation caused by these activities and build economic incentives for the improvement of productive systems, based on agroecological practices that allow transitions towards sustainability (5.2.2.1).

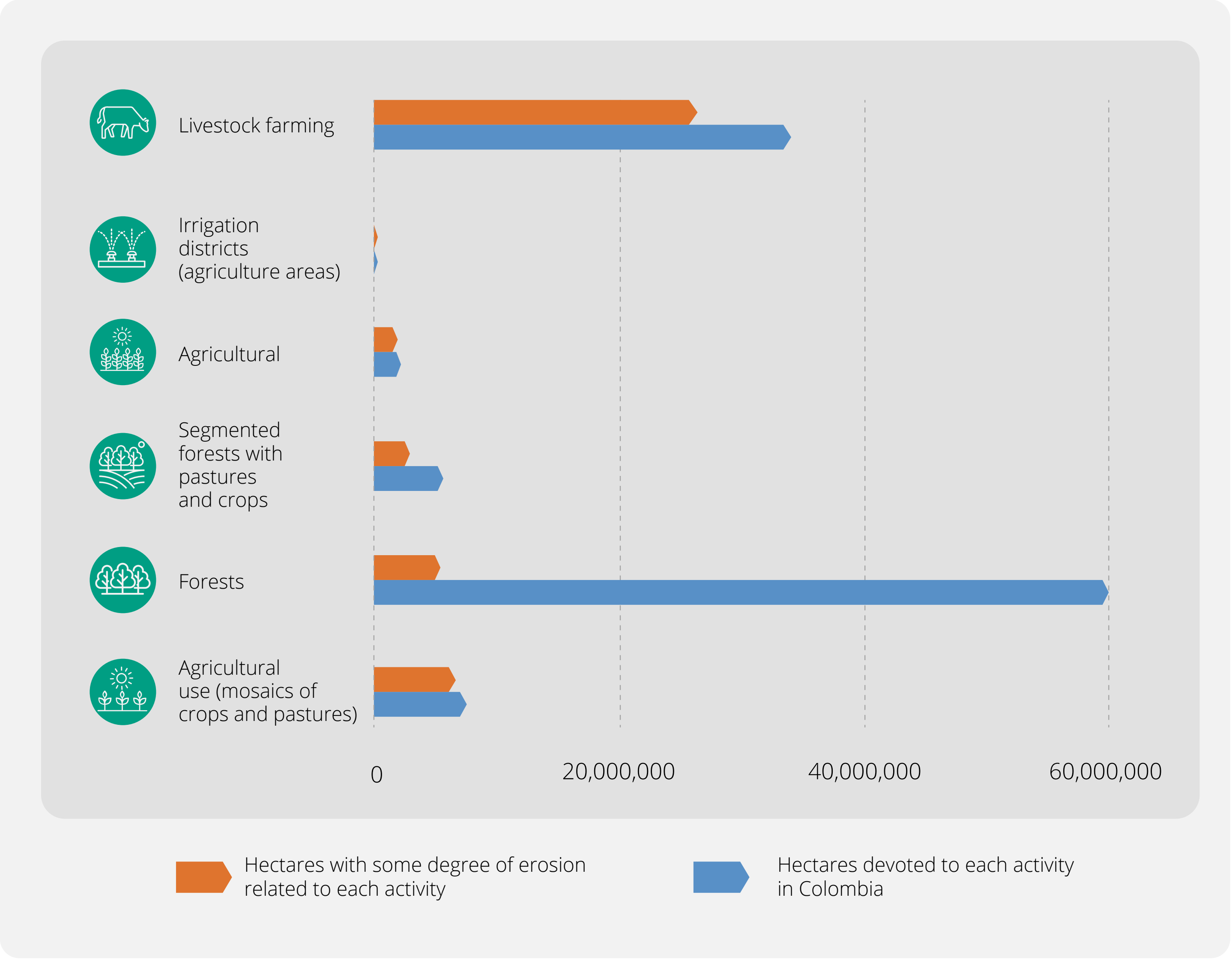
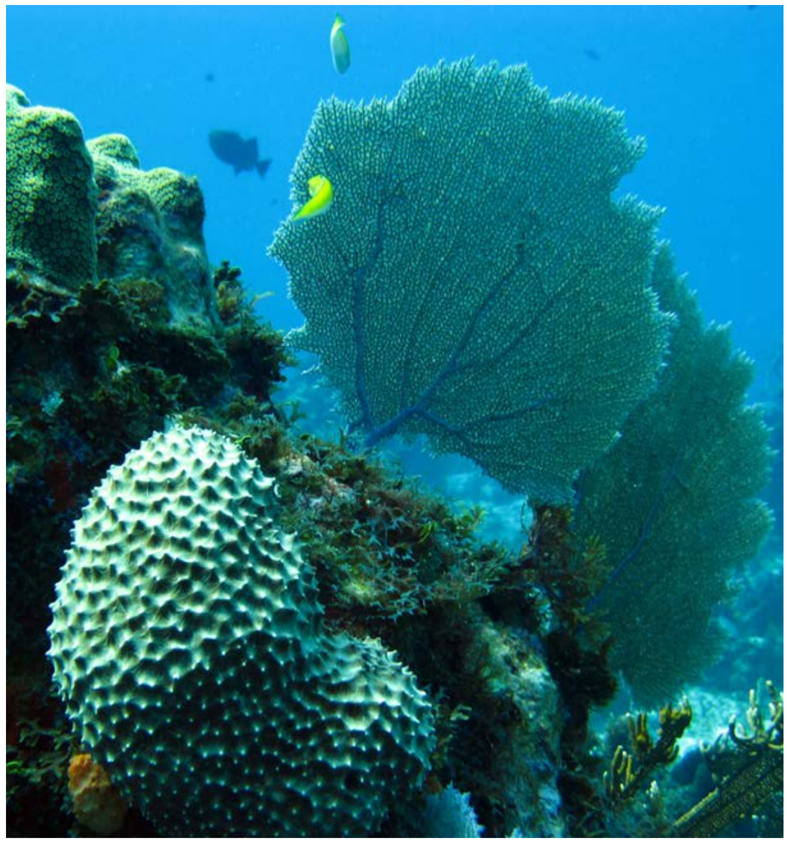
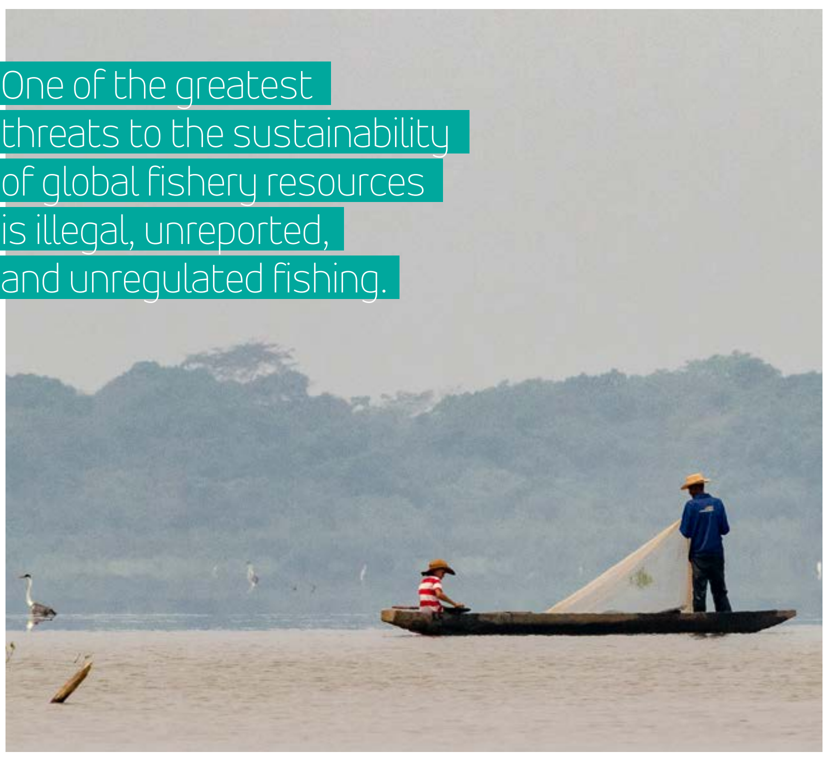


Figure 8. Soil use and erosion in Colombia. Based on Ideam et al. (2015).

While there are not many robust fisheries assessments in marine environments, there has been a noticeable decline in landings in the Pacific (from 80,000 tn between the 1990s and 2005 to around 40,000 tn since 2012; INVEMAR, 2019). Based on available information, the National Authority of Aquaculture and Fisheries (AUNAP) assessed 69 freshwater or marine fishery resources in 2014, finding that 48% were overexploited, 23% were fully exploited, and 8% appeared to be underexploited, while the exploitation status of the remaining species could not be determined (Puentes et al., 2014[85]). As is the case in other parts of the world, one of the greatest threats to the sustainability of global fishery resources is illegal, unreported, and unregulated fishing (FAO, 2018[86]). This issue has been identified in Colombia, both in San Andrés and Providencia Islands and along the Pacific and Caribbean coasts, suggesting that actual catches are double the officially reported figures (Wielgus et al., 2010[87]). By preserving buffer strips and hydroecological connectivity, purifying contaminated basins, and fully understanding the ecological cycles of fishery resources, it will be possible to design strategies to restore water bodies and their connectivity for effective reproductive migrations of key species exploited in fishing activities. It will also enable the development of technological strategies for assisted reproduction and restocking of commercially valuable fish species in water bodies with limited functionality (5.2.6.2).



By 2100, about 35.3% of corals will be exposed to sea surface temperatures (SST) above 28.9 °C.



> One of the greatest threats to the sustainability of global fishery resources is illegal, unreported, and unregulated fishing.

Biological invasions significantly impact the integrity of the ecosystem *(Established but incomplete).* The introduction of aquatic predators such as the lionfish (*Pterois volitans*) in the Colombian Caribbean has resulted in the loss or decrease of native reef species populations and the alteration of the natural trophic network. In terrestrial ecosystems, changes in high Andean plant communities due to the expansion of invasive plants, such as gorse (*Ulex europaeus*) and Montpellier broom (*Genista monspessulana*), modify the natural fire regime in high Andean forest and paramo ecosystems, altering ecological succession processes, the persistence of native plant species, and the provision of habitat and food

[85] Puentes, V; Escobar, F. D.; Polo, C. J., and Alonso, J. C. (Eds.) (2014). Estado de los Principales Recursos Pesqueros de Colombia 2014. [Status of Colombian Main Fishery Resources, 2014] Fishery resources in Colombia - National Authority of Aquaculture and Fisheries (AUNAP) Office of the Generation of Knowledge and Information of the National Authority of Aquaculture and Fisheries (AUNAP) 244 p.

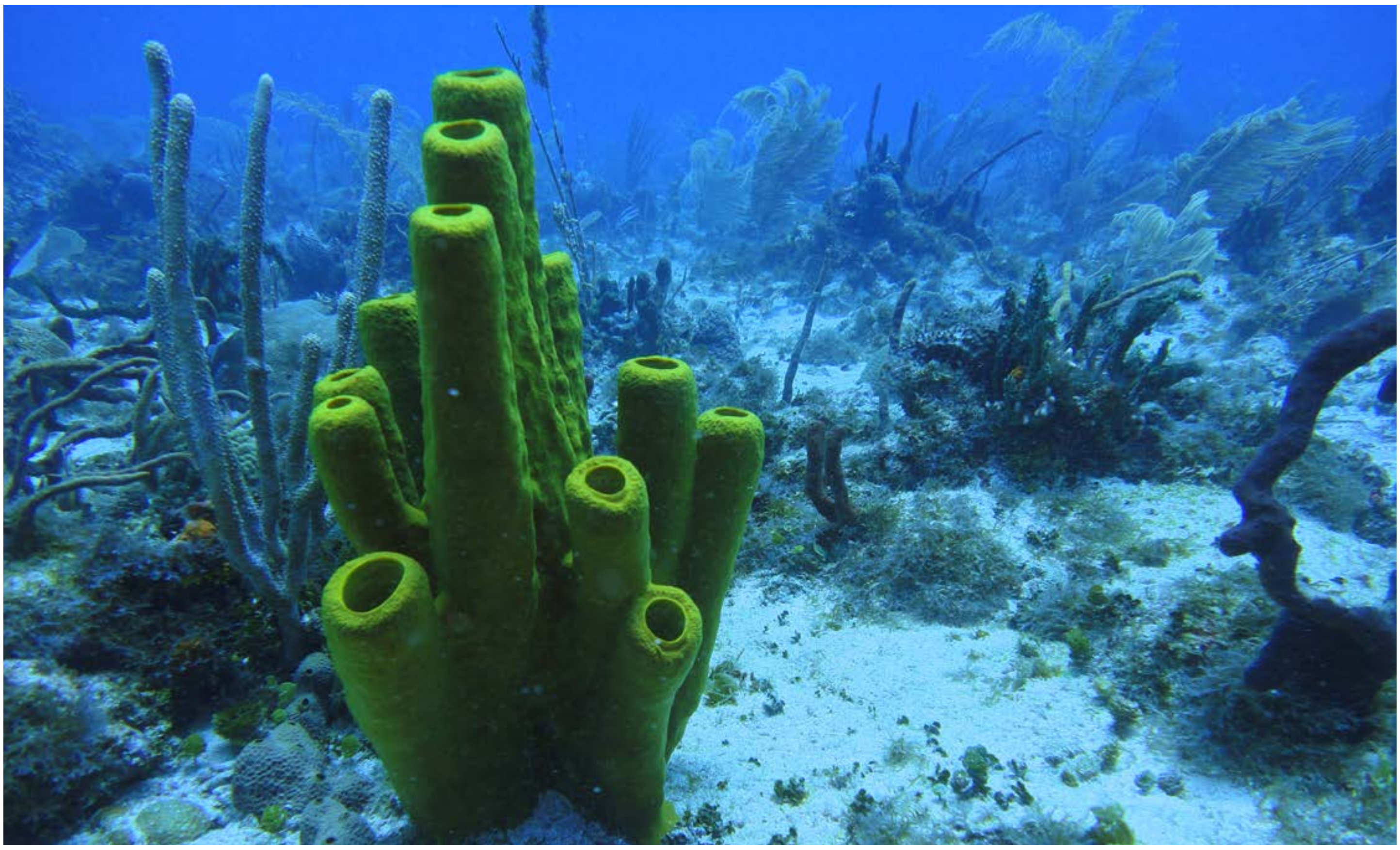
[86] FAO - Food and Agriculture Organization of the United Nations. (2018). The State of World Fisheries and Aquaculture 2018. Meeting the sustainable development goals. Rome.

[87] Wielgus, J., D. Zeller, D. Caicedo-Herrera and R. Sumaila. (2010). Estimation of fisheries removals and primary economic impact of the small-scale and industrial marine fisheries in Colombia. Marine Policy, 34, 506-513.

for local fauna. In productive ecosystems with temperate and warm climates, the crazy ant (*Nylanderia fulva*) attacks crops (such as sugarcane, citrus fruits, coffee, corn, cassava, plantain, guava, among others) and preys on wild and farm animal species, affecting biodiversity and decreasing farm productivity (Figure 9).

In general, whenever invasive species are detected, it is usually already too late, and their impact is irreversible. The lionfish (*Pterois volitans*) was first detected in late 2008 on Providencia Island, and today it has spread as a plague from Capurganá to La Guajira, passing through the San Bernardo and Rosario Islands, and the surroundings of Tayrona Park. This species is currently recognised as the fastest and worst-documented marine invasion caused by a fish in history. González et al. (2016[88]) calculated an average density of 397 lionfish per hectare in the coral areas of San Andrés Island, one of the highest figures from the invaded area (Western Atlantic), and it is estimated that the lionfish invasion could result in the loss of 80% of fish species within a reef.

Furthermore, the introduction of species for aquaculture production has been a driver of biodiversity loss in Colombia. One example is the extinction of the greasefish *Rhizosomichthys totae,* endemic to Laguna de Tota in Boyacá, caused by the introduction of species such as rainbow trout. Even acknowledging that there could be a significant environmental impact, many promising species have historically been introduced because their reproductive biology is known and there are already standardised technological strategies available, which implies savings in agronomic and livestock research. However, such savings are negligible, since the adaptation process to Colombian conditions entails high costs that are not absorbed by the production process, and are eventually subsidised by local and national economies. Investment in science and technology for the development of technological breeding strategies of native species for commercial purposes can achieve a better balance between financial losses and gains, and biodiversity. In addition, greater efforts to detect and control biological invasive species must be devoted, but strict biosecurity protocols for the management of promising exotic species for commercial purposes should also be implemented (5.2.6.4; 5.2.7).



Coral reefs mitigate coastal erosion by 55% to 94%.

[88] González-Corredor, J.D., A. Acero P. and R. García-Urueña. (2016). Densidad y estructura de tallas del pez león *Pterois volitans* (Scorpaenidae) en el Caribe occidental insular colombiano. [Density and size structure of the lionfish ***Pterois volitans*** (Scorpaenidae) in the Colombian insular western Caribbean] Bol. Inv. Mar. Cost., 45(2), 317-333.

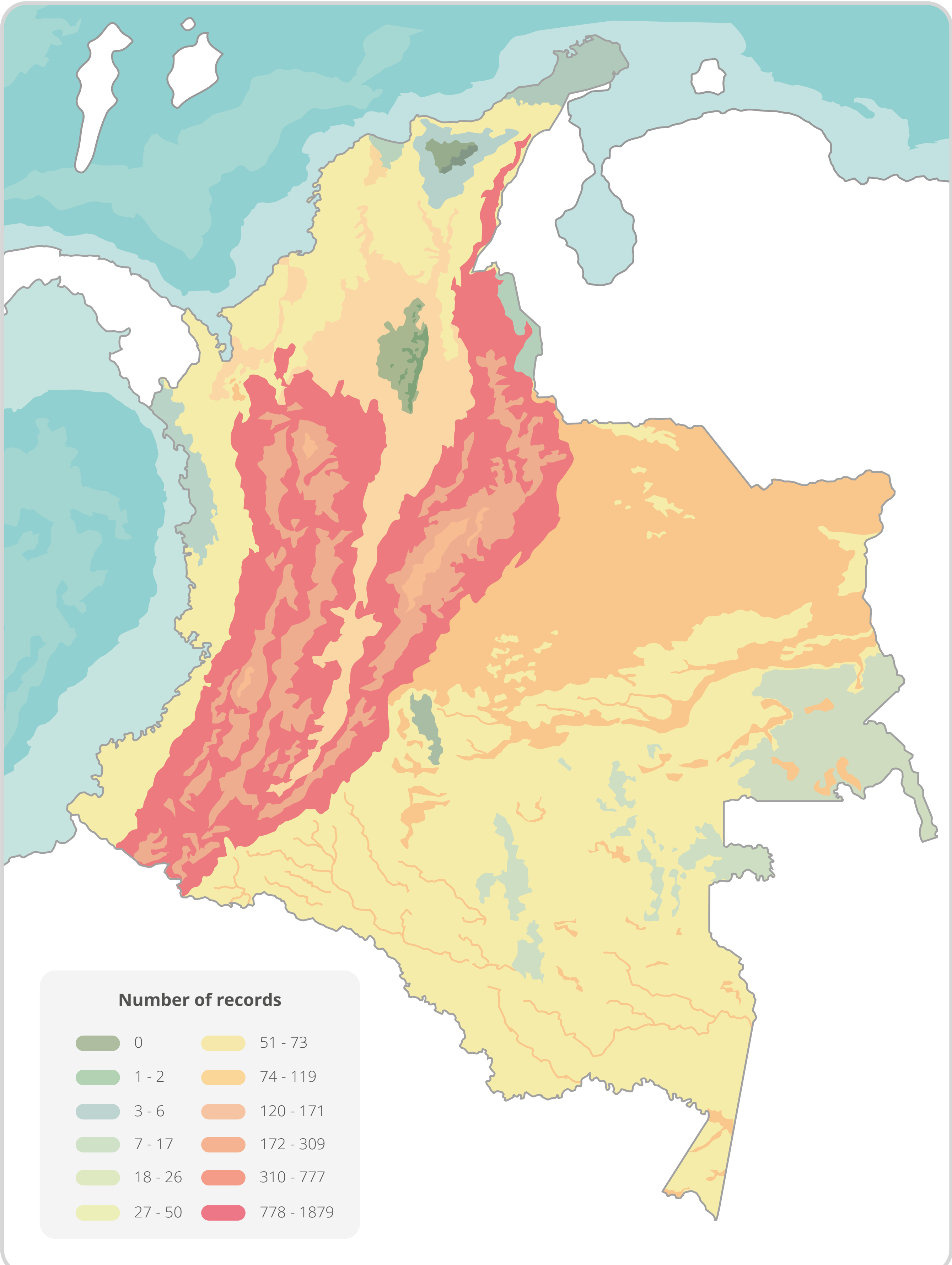


Figure 9. Number of records of high-risk invasive species by biome in Colombia (including introduced and transplanted ones). Retrieved from Minambiente and PNUD, 2014[89].

89 González-Corredor, J.D., A. Acero P. and R. García-Urueña. (2016). Densidad y estructura de tallas del pez león Pterois volitans (Scorpaenidae) en el Caribe occidental insular colombiano. [Density and size structure of the lionfish Pterois volitans (Scorpaenidae) in the Colombian insular western Caribbean] Bol. Inv. Mar. Cost., 45(2), 317-333.

The studies on indigenous and local knowledge about climate change are scarce, as well as their integration into regional and national adaptation measures, despite that such integration has been widely recommended and could be a significant contribution (*Established but incomplete*). In Colombia, the development of models and change scenarios in marine and coastal ecosystems is incipient, and those that exist focus on the effects of climate change on sea surface temperature (SST) increase, sea level rise (SLR), and changes in coastline (CLC). The effects of these changes will be perceived in coral reefs, mangroves, and seagrasses through coral bleaching, species mortality, and habitat loss (4.2; 4.5; 7.3.2.3; 7.3.5).

It is necessary to take actions for strengthening marine and coastal territory management and planning *(Established but incomplete).* The **2016-2100 climate change scenarios for the Colombian coastal zone,** based on Representative Concentration Pathways (RCP) 4.5 and 6.0, **indicate that, by 2100, about 35.3% of corals will be exposed to sea surface temperatures (SST) above 28.9°C, with the corals from the archipelagos of El Rosario and San Bernardo being the most affected**. In seagrass meadows, the SST trend has lower influence than in corals; however, by 2100, around 7% of seagrass meadows would be exposed to SST exceeding 30°C and would begin to experience thermal stress (Gómez et al., 2014[90]). Regarding ocean acidification, the models in place are very general, and the country lacks detailed information to measure acidification at a local scale. Therefore, it is necessary to make considerable investments in order to evaluate impacts at a more detailed scale (Ideam et al., 2017[91]). On the other hand, the instruments included in Law 99 of 1993 have proven limited for the conservation of marine and coastal ecosystems. It is necessary to establish transformative changes and socio-ecological transitions towards sustainability, supported by scientific knowledge and intercultural dialogue, as well as the involvement of civil society and development sectors, productive associations, and companies, aiming at adapting to climate change through nature-based solutions, to ensure the services of regulatory ecosystems such as coral reefs, seagrass meadows, mangroves, and wetlands (7.3.2.3; 7.3.5).

Mangroves, coral reefs, and wetlands are key ecosystems in Colombia for mitigating the effects of climate change and extreme events *(Well established)*. It is estimated that mangroves and coral reefs mitigate coastal erosion by 55% to 94%; and in particular cases, such as the coral reef in Isla Tesoro at the Rosario Islands, it was discovered that this barrier reef dissipates wave height by 84% in 600 m (Osorio-Cano et al., 2018[92]) and thus most of the wave energy is dissipated, contributing to erosion mitigation. Coral reefs and adjacent ecosystems such as seagrasses and mangroves protect coasts from erosion and extreme weather events like storms, hurricanes, tsunamis, and sea level rise (Prato, 2014[93]; Polanía et al., 2015[94]; Osorio et al., 2016[95]). Furthermore, marine and coastal ecosystems are temporary or permanent habitats for flora and fauna species, including turtles, fish, dolphins, rays, octopuses, sea urchins, starfish, and seahorses (Díaz et al., 2003[96]), which are essential for the development of ecotourism and recreational activities such as diving and snorkelling. They are also all important in providing food and recreation.

In San Andrés and Providencia, there is an estimated potential annual income of USD241 million from sustainable ecotourism development (James & Márquez, 2011[97]). Prato and Newball (2015[98]) estimated the economic value provided by marine and coastal ecosystems in the Seaflower Biosphere Reserve at nearly USD267.339 billion a year, taking into account the extent of mangroves, seagrasses, coral reefs, and open ocean, as well as values reported in other studies (Costanza et

90 Gómez-López, D.I, C. Díaz, E. Galeano, L. Muñoz, S. Millán, J. Bolaños and C. García. 2014. Informe técnico Final Proyecto de Actualización cartográfica del atlas de pastos marinos de Colombia: Sectores Guajira, Punta San Bernardo y Chocó: Extensión y estado actual. [Final Technical Report: Cartographic Update Project of the Seagrass Atlas of Colombia: Guajira, Punta San Bernardo, and Chocó Areas; Extension and Current Status] PRY- BEM-005-13 (Inter-administrative agreement 2131068 FONADE – INVEMAR). INVEMAR, MADS, FONADE and ANH. Limited circulation. Santa Marta. 136 p

91 Ideam, PNUD, MADS, DNP, CHANCELLERY. 2017. Colombia's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC). Colombia's Third National Communication on Climate Change. Bogotá D.C., Colombia.

92 Osorio-Cano, J. D., Alcérreca-Huerta, J. C., Osorio, A. F., & Oumeraci, H. (2018). CFD modelling of wave damping over a fringing reef in the Colombian Caribbean. Coral Reefs, 37(4), 1093-1108.

93 Prato J.A. 2014. Importancia económica de nuestros mares: Capital natural marino y costero de Colombia. [Economic Relevance of our Seas: Natural Capital of the Colombian Coastal and Marine Systems] La Timonera, 22: 32-37.

94 Polanía, J., Urrego, L.E., and Agudelo, C.M. 2015. Recent advances in understanding Colombian mangroves. Acta Oecologica 63: 82-90.

95 Osorio A.F., Ortega S., Arango-Aramburo, S. 2016. Assessment of the marine power potential in Colombia. Renewable and Sustainable Energy Reviews, 53: 966-977. Doi:10.1016/j.rser.2015.09.057

96 Díaz, J.M., L. M. Barrios and D. I. Gómez-López (eds). 2003. Las praderas de pastos marinos en Colombia: Estructura y distribución de un ecosistema estratégico. [Seagrass Meadows in Colombia: Structure and Distribution of a Strategic Ecosystem] Invemar, Serie de Publicaciones Especiales #10, Santa Marta, 160 p.

97 James, J. and C. Márquez. 2011. Valoración Económica del buceo, como estrategia de uso sostenible de la biodiversidad marina, Archipiélago de San Andrés y Providencia, Caribe Colombiano. [Economic Value of Diving as a Sustainable Strategy for Marine Biodiversity, Archipelago of San Andrés, Providencia and Santa Catalina, Colombian Caribbean] Rev. Gest. Amb, 14(1), 37-54.

98 Prato, J. and R. Newball. 2015. Aproximación a la valoración económica ambiental del departamento Archipiélago de San Andrés, Providencia y Santa Catalina – Reserva de la Biósfera Seaflower. [First Steps Towards the Environmental Economic Valuation of the Archipelago of San Andrés, Providencia, and Santa Catalina - Seaflower Biosphere Reserve] Executive Secretary of the Colombian Ocean Commission (SECCO), Division for the Sustainable Development of the Archipelago of San Andrés, Providencia and Santa Catalina (Coralina). Bogotá, 170 pp.

al., 1997[99]; Costanza et al., 2014[100]; Van der Ploeg and de Groot, 2010[101]). In this regard, simply complying with the law on national assets and systematically implementing the Policy for the Integral Management of Biodiversity and its Ecosystem Services (Minambiente, 2011) would be sufficient for the conservation, sustainable use, and enjoyment of these systems and the services they provide (3.2.6; 3.2.7; 3.2.13).

It is estimated that around 35% of the Colombian population directly benefits from water derived from high mountain ecosystems, such as cloud forests and paramos *(Well established)*. The paramo ecosystem directly benefits populations in 16 cities in the country, impacting on 16.8 million inhabitants or 35% of the national population (Moreno et al., 2016[102]). Aquifers and wetland areas covering more than 26% of the national territory are also crucial for water supply (Jaramillo et al., 2016), making Colombia exceptionally rich in water sources. However, areas affected by water scarcity have increased, and therefore, nearly 20% of the Colombian population is exposed to it. To illustrate, the vast majority of the capital cities in Colombia (Special Category 1 and 2) depend on water sources outside their political-administrative jurisdiction for their water supply. This not only generates dependence on other regions but also poses the challenge of updating regulations and economic instruments for their protection. Most municipalities in Categories 3, 4, 5, and 6 depend on a single water source for their supply, leading to a high vulnerability for the continuity of this ecosystem service (Ideam, 2018a[103]). In this sense, urban expansion policies must consider not only the availability of water resources, but also the development of broad supply opportunity portfolios, considering the models, scenarios, and projections provided by the Intergovernmental Panel on Climate Change (IPCC), as well as adequate and consensus-based water-saving policies supported by economic incentives (3.2.4).

Sustainable water management will be a major challenge of decision-making processes at all levels, since the amount of water that the country will demand by 2022 will be greater than the supply and will be concentrated in the demand of the productive sectors, especially the agricultural *(Well established).* Data on the effects of climate change on precipitation and water resources for Colombia are scarce, and much data is not compiled nor accurate. However, the information available so far indicates that, by 2050, there will be an increase in precipitation in the Andean region and a reduction in the north of the country. In general, the existing information shows that rainfall in Colombia will be reduced in some areas while in other areas it will be increased. Authors agree that regions where precipitation will increase by 2050 include the central and northern Pacific, the Magdalena Medio, the Bogotá savannah, Sogamoso, the Catatumbo and Arauca valleys. In contrast, the Llanero and Amazonian foothills, the central Orinoquia, the central Amazon region, and the Caribbean region will experience a reduction in precipitation between 10% and 15% by 2050 (7.3.5).

The low water retention capacity of soils, the predicted temperature elevation for Colombia under climate change scenarios, and the deforestation projected in future scenarios following the current trend[104] will enhance water loss through evaporation *(Established but incomplete)*. According to studies by IGAC (2015), 89% of Colombian soils, covering 49% of the national territory, have a water retention capacity available for plant consumption ranging from low to medium (IGAC, 2015[105]). In addition, the predicted temperature elevation for Colombia under climate change scenarios, and **the deforestation projected in future scenarios following the current trend will enhance water loss through evaporation**.

Consequently, due to the increased water demand from agricultural expansion, commercial exploitation of soils in Colombia will necessarily depend on additional water supply beyond what is naturally available. To achieve this goal, it is recommended to design a strategy for conserving key ecosystems in water and nutrient supply, determine the thresholds for land use change that ensure the ecosystem functionality of new agricultural regions, and build infrastructure works required to supply the future water demand (7.3.3).

99 Costanza, R., R. D'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, & M. Van Den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253 – 260p.

100 Costanza, R., R. De Groot, P. Sutton, S. der Ploeg, S.J. Anderson, I. Kubiszewski, S. Farber & R.K. Turner. 2014. Changes in the global value of ecosystem services. Global Environ. Change 26, 152–158.

101 Van der Ploeg, S. & R.S. de Groot. 2010. The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, Wageningen, the Netherlands.

102 Moreno, L. A., Andrade, G. I., and Ruíz-Contreras, L. F. (2016). Biodiversidad 2016. Estado y tendencias de la biodiversidad continental de Colombia. [Status and Trends of Colombian Continental Biodiversity] Bogotá, Alexander von Humboldt Biological Resources Research Institute. Bogotá, D. C., Colombia. 3: 106.

103 Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) (2018a). 2017 Results from Monitoring Deforestation in Colombia. URL: http://documentacion.ideam.gov.co/openbiblio/bvirtual/023835/Resultados_Monitoreo_Deforestacion_2017.pdf

104 According to the National Plan of Development 2018-2022: "Pact for Colombia, pact for equity" (National Planning Department, 2019), between 2005 and 2015, 1.5 million hectares of forest were lost, and in the last two years, 178,000 and 219,000 hectares were deforested.

105 Geographic Institute "Agustín Codazzi" (IGAC). (2015). Suelos y Tierras de Colombia. [Colombian Soils and Lands] Subdirectorate of Agrology of the Agustin Codazzi Geographic Institute (IGAC).

Climate change is accelerating the transformation of biodiversity and the loss of nature's contributions to people throughout the national territory *(Established but incomplete)*. The largest source of CO2 emissions in Colombia is the AFOLU sector (Agriculture, Forestry, and Other Land Use), with an average of 115,847 Gg of CO2 eq, representing 55% of the total emissions. Within this average, 79.23 Mt of CO2 eq come from forest land management, while 52.00 Mt of CO2 eq come from agricultural activities. Following this, the energy sector contributes 35% of emissions, followed by industrial processes and product use at 4%, and finally, waste at 6% (Ideam, 2018b[106]). Evidence of climate change in the country indicates an increase in average air temperature, ranging from +0.1 to +0.2 °C per decade since the mid-20th century, and an increase in maximum temperature of around +0.6 °C per decade, with regional variations in total annual precipitation ranging from -4% to +6% (Ideam and Ruiz, 2010[107]; Pabón, 2012[108]).

Flora and fauna of tropical mountains are susceptible to the effects of climate change because many species have majority of species have narrow altitudinal ranges, and small changes can result in local extinctions. The Amazon, Andean, and Caribbean regions are particularly vulnerable (Laurance et al., 2011[109]). There is evidence that bird and amphibian species from warm areas have been migrating to higher altitudes, causing alterations in their abundance, distribution, and representation.
Agrobiodiversity has also been influenced by the effects of climate change due to the sector's dependence on climate conditions. Significant changes have been identified in the optimal production areas for nine prioritised crops in the Cundinamarca region, which are already experiencing alterations due to increased temperatures and reduced precipitation: rice, peas, sugarcane, beans, corn, Pastusa potato, Creole potato, plantain, and cassava.

Likewise, on the Colombian coast, coral bleaching has increased in the last 20 years in both frequency and intensity, mainly affecting 30% of the Colombian Caribbean basin, primarily in the Los Corales del Rosario and San Bernardo National Natural Parks. Corals are particularly sensitive to high water temperatures, which can cause irreversible damage and subsequent death of these natural systems. Nonetheless, important adaptation and mitigation efforts can be found, based on ecosystems and communities, which have provided solutions with territorial identity to increase response capacity to climate change threats and impacts. Examples include intervention projects in the southern Mojana region driven by the Green Climate Fund, with over 1,000 hectares rehabilitated with local Mojana communities (5.4.2.2; 5.2.4.3).

[106] Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) (2018b). Second Biennial Update Report on Greenhouse Gas Emissions. Executive Summary. Colombia's Third National Communication on Climate Change.

[107] IDEAM and Ruiz. (2010). Cambio climático en temperatura, precipitación y humedad relativa para Colombia usando modelos meteorológicos de alta resolución (Panorama 2011-2100). [Climate Change in Temperature, Precipitation, and Relative Humidity for Colombia Using High-resolution Meteorological Models (Overview 2011-2100)] Ideam-Meteo 005-2010, p. 60 [Technical report]. Bogotá, Colombia.

[108] Pabón, J. (2012). Cambio climático en Colombia: tendencias en la segunda mitad del siglo XX y escenarios posibles para el siglo XXI. [Climate Change in Colombia: Trends in the Second Half of 20th Century and Possible Scenarios for 21st Century] Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales, 36(139), 261-278. ISSN 0370-3908.

[109] Laurance, W. F., Camargo, J. L. C., Luizão, R. C. C., Laurance, S. G., Pimm, S. L., Bruna, E. M., ... Lovejoy, T. E. (2011). The fate of Amazonian forest fragments: A 32-year investigation. Biological Conservation, 144(1), 56–67. https://doi.org/10.1016/j.biocon.2010.09.021

4 Appendix

4.1. Conceptual Framework and Definitions

The objectives of IPBES is "to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity, long-term human wellbeing and sustainable development." To achieve this goal, the Platform established a conceptual framework that includes six interlinked elements constituting a social-ecological system that operates at various scales in time and space: nature; nature's benefits to people; anthropogenic assets; institutions and governance systems and other indirect drivers of change; direct drivers of change; and good quality of life (IPBES, 2013[110]).

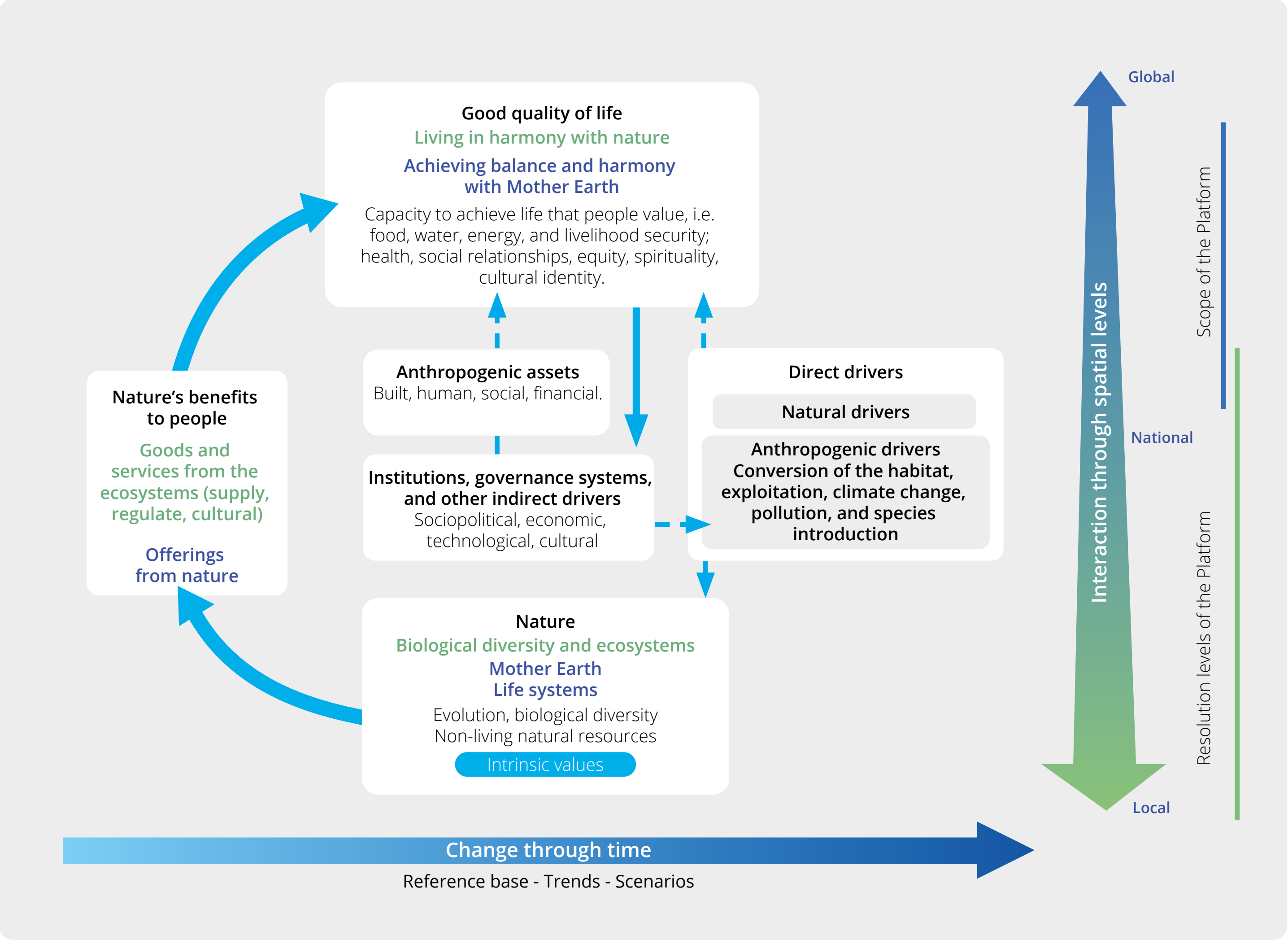


Figure 4.1.1. Conceptual Framework of the Platform. In the main panel, ***nature, nature's benefits to people*** and ***good quality of life*** (indicated as black headlines) are inclusive of all these world views; text in green denotes the concepts of science; and text in blue denotes those of other knowledge systems. Solid arrows in the main panel denote influence between elements; the dotted arrows denote links that are acknowledged as important, but are not the main focus of the Platform. The thick coloured arrows below and to the right of the central panel indicate different scales of time and space, respectively (IPBES, 2013).

[110] IPBES (2013). Conceptual framework for the intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES, Decision IPBES-2/4). https ://www.ipbes .net/sites /default/files /downloads/Decision%20 IPBES_2_4.pdf.

The National Assessment was performed by over 100 experts and wise representatives from indigenous peoples and communities, Black and Afro-descendant communities, Palenqueros, Raizales, rural and other local communities from Colombia.

Nature in the context of the Platform refers to the natural world with an emphasis on biodiversity. Within the context of science, it includes categories such as biodiversity, ecosystems, ecosystem functioning, evolution, the biosphere, humankind's shared evolutionary heritage, and biocultural diversity. Within the context of other knowledge systems, it includes categories such as Mother Earth and systems of life. Other components of nature, such as deep aquifers, mineral and fossil reserves, and wind, solar, geothermal and wave power, are not the focus of the Platform. Nature contributes to societies through the provision of benefits to people and has its own intrinsic values, that is, the value inherent to nature, independent of human experience and evaluation and thus beyond the scope of anthropocentric valuation approaches.

Anthropogenic assets refers to built-up infrastructure, health facilities, knowledge (including indigenous and local knowledge systems and technical or scientific knowledge, as well as formal and non-formal education), technology (both physical objects and procedures), and financial assets, among others. Anthropogenic assets have been highlighted to emphasise that a good life is achieved by a collaborative production of benefits between nature and societies.

Nature's benefits to people refers to all the benefits that humanity obtains from nature. Ecosystem goods and services, considered separately or in bundles, are included in this category. Within other knowledge systems, nature's gifts and similar concepts refer to the benefits of nature from which people derive a good quality of life. Aspects of nature that can be negative to people, such as pests, pathogens or predators, are also included in this broad category.

Drivers of change refers to all those external factors that affect nature, anthropogenic assets, nature's benefits to people and a good quality of life. They include institutions and governance systems and other indirect drivers and direct drivers.

Institutions and governance systems and other indirect drivers are the ways in which societies organise themselves, and the resulting influences on other components. There are the underlying causes of environmental change that are exogenous to the ecosystem in question. Because of their central role, influencing all aspects of human relations with nature, these are key levers for decision-making processes. Institutions encompass all formal and informal interactions among stakeholders and social structures that determine how decisions are taken and implemented, how power is exercised, and how responsibilities are distributed.

Direct drivers, both natural and anthropogenic, affect nature directly. *Natural drivers* are those that are not the result of human activities and are beyond human control. These include earthquakes, volcanic eruptions and tsunamis, extreme weather or ocean-related events such as prolonged drought or cold periods, tropical cyclones and floods, the El Niño/La Niña, Southern Oscillation, and extreme tidal events. The direct anthropogenic drivers are those that are the result of human decisions, namely, of institutions and governance systems and other indirect drivers. Anthropogenic drivers include habitat conversion, e.g., degradation of land and aquatic habitats, deforestation and afforestation, exploitation of wild populations, climate change, pollution of soil, water and air and species introductions. Some of these drivers, such as pollution, can have negative impacts on nature; others, as in the case of habitat restoration, or the introduction of a natural enemy to combat invasive species, can have positive effects.

Good quality of life is the achievement of a fulfilled human life, a notion which varies strongly across different societies and groups within societies. It is a context-dependent state of individuals and human groups, comprising access to food, water, energy and livelihood security, and also health, good social relationships and equity, security, cultural identity, and freedom of choice and action. From virtually all standpoints, a good quality of life is multidimensional, having six material as well as immaterial and spiritual components. What a good quality of life entails, however, is highly dependent on place, time and culture, with different societies espousing different views of their relationships with nature and placing different levels of importance on collective versus individual rights, the material versus the spiritual domain, intrinsic versus instrumental values, and the present time versus the past or the future (IPBES, 2014).

Interlinkages between the elements of the conceptual framework

A society's achievement of good quality of life and the vision of what this entails directly influence institutions and governance systems and other indirect drivers and, through them, they influence all other elements.

Good quality of life, and views thereof, also indirectly shape, via institutions, the ways in which individuals and groups relate to nature. Perceptions of nature range from nature being considered as a separate entity to be exploited for the benefit of human societies to nature being seen as a sacred living entity of which humans are only one part.

Institutions and governance systems and other indirect drivers affect all elements and are the root causes of the direct anthropogenic drivers that directly affect nature. For example, economic and demographic growth and lifestyle choices (indirect drivers) influence the amount of land that is converted and allocated to food crops, plantations or energy crops; accelerated carbon-based industrial growth over the past two centuries has led to anthropogenic climate change at the global scale. All of these have strong effects on biodiversity, ecosystem functioning and their derived benefits and, in turn, influence different social arrangements intended to deal with these problems.

Institutions and governance systems and other indirect drivers also affect the interactions and balance between nature and human assets in the collaborative production of nature's benefits to people, for example by regulating urban sprawl over agricultural or recreational areas. This element also modulates the link between nature's benefits to people and the achievement of a good quality of life, for example, by different regimes of property and access to land and goods and services; transport and circulation policies; and such economic incentives as taxation or subsidies. For each of nature's benefits that help to achieve a good quality of life, the contribution of institutions can be understood in terms of instrumental value, such as access to land that enables the achievement of high human wellbeing, or in terms of relational values, such as regimes

of property that both represent and allow human lives deemed to be in harmony with nature.

Direct drivers cause a change directly in the ecological system and, as a consequence, in the supply of nature's benefits to people. Natural drivers of change affect nature directly. For example, the impact by a massive meteorite is believed to have triggered one of the mass extinctions of plants and animals in the history of life on Earth. Furthermore, a volcanic eruption can cause ecosystem destruction, at the same time serving as a source of new rock materials for fertile soils. In addition, these seven anthropogenic assets directly affect the possibility of leading a good life through the provision of (and access to) material wealth, shelter, health, education, satisfactory human relationships, freedom of choice and action, and sense of cultural identity and security (IPBES, 2014).

4.2 Description of confidence terms

Science relies on academic support, based on citations with findings that can reinforce each statement; in these assessments where a wide range of topics and knowledge systems are covered, findings supported by a diverse number of sources and types of studies are frequently present. This is why IPBES globally establishes ***confidence terms*** associated to each one of the key findings.

In this Assessment, the degree of confidence in each key message is based on the quantity and quality of evidence, and the level of agreement among that evidence (Figure 4.2.1). The evidence includes data, theory, models, and expert opinions. The Secretariat's note on information regarding guidance on assessment production (IPBES/6/INF/17) provides a more extensive documentation of the approach.

The terms used to classify the evidence are:

- Well established: Comprehensive meta-analysis or other synthesis or multiple independent studies that agree.
- Established but incomplete: General agreement although only a limited number of studies exist but no comprehensive synthesis and, or the studies that exist imprecisely address the question.
- Unresolved: Multiple independent studies exist but conclusions do not agree.
- Inconclusive: Existing as or based on a suggestion or speculation; no or limited evidence.

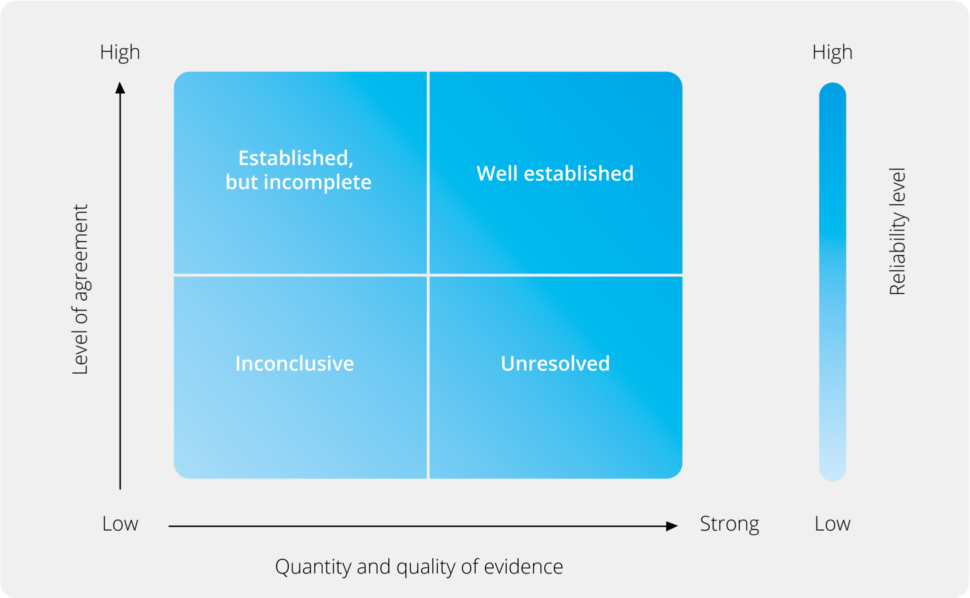


Figure 4.2.1. Four-box model for the qualitative communication of confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Source: IPBES, 2016.

Recognising and articulating community knowledge and governance systems along with environmental institutional frameworks is urgently needed.

4.3 Categories of Nature's Contributions to People

The specific categories of nature's contributions to people (NCP) adapted to the Colombian context, retrieved from Figure 1 in the report of the fifth session of the Platform's Plenary (IPBES/5/INF24), are (Figure 4.3.1):

Tabla 4.3.1 Nature's contributions to people (NCP) adapted to the Colombian context

CATEGORIES	BRIEF EXPLANATION AND EXAMPLES
1. Habitat creation and maintenance	Formation and continued production, by ecosystems or organisms within them, of ecological conditions necessary or favourable for organisms important to humans. It includes nesting, feeding, mating, resting and overwintering areas for migratory fish, birds and mammals. It also includes green areas in cities and wildlife corridors to preserve biodiversity.
2. Pollination and dispersal of seeds and other propagules	Animals contribute to the movement of pollen among flowers, and dispersal of seeds, larvae or spores of organisms important to humans.
3. Regulation of air quality	Ecosystems regulate air quality through filtration, fixation, degradation or storage of atmospheric pollutants; they also preserve $CO2/O2$ balance, and other components that could become pollutants if present in large quantities.
4. Regulation of climate	Ecosystems regulate climate in different ways, including the capture of emissions of greenhouse gases, and the alteration of albedo, radiation, and evapotranspiration.
5. Regulation of ocean acidification	Photosynthetic organisms regulate atmospheric CO2 concentrations and seawater pH, which affect associated calcification processes by many marine organisms important to humans, such as corals.
6. Regulation of freshwater quantity, location and timing	Ecosystems regulate the quantity, location and timing of the flow of surface and groundwater used for drinking, irrigation, transport, hydropower, and as the support of non-material contributions, such as identity development (fishing communities) and physical and psychological experiences (sports, entertainment). Ecosystems also regulate flooding that affect bodies of water regularly used by the population.
7. Regulation of freshwater and coastal water quality	Organisms or ecosystems regulate water quality through filtration of particles, pathogens, excess nutrients, and other chemicals.
8. Formation, protection and decontamination of soils and sediments	Sediment retention and erosion control, soil formation and maintenance of soil structure and the processes that take place. In the Colombian context, this is particularly related to organic carbon stored within soils, and its capacity to control erosion and sediments.
9. Regulation of hazards and extreme events	Ecosystems ameliorate the impacts on humans or their infrastructure caused by natural events (e.g. strong winds, frosts, droughts, flash floods, overflows, floods, wildfires, mass movements, etc.).

CATEGORIES	BRIEF EXPLANATION AND EXAMPLES
10. Regulation of organisms detrimental to humans	Ecosystems or organisms regulate pests, pathogens, predators, competitors, etc. that affect humans, plants and animals. This includes: i) regulation by predators or parasites of the population size of non-harmful important animals; ii) regulation of the abundance or distribution of potentially harmful organisms; iii) removal of animal carcasses and human corpses by scavengers; iv) regulation of biological impairment and degradation of infrastructure (e.g. damage by termites).
11. Energy	Extraction and generation of energy from primary sources, as well as production of biomass-based fuels (such as biofuel, fuelwood, and animal waste).
12. Food and feed	Production of food for human consumption (fish, beef, poultry, dairy products, etc.) and feed for animals (grass and grains) from wild, managed, or domesticated organisms.
13. Materials and assistance	Production of materials derived from organisms in crops or wild ecosystems, for different uses such as construction, clothing, printing, and ornamental purposes. It includes direct use of living organisms for decoration (i.e. ornamental plants in parks and households, ornamental fish), pets, transport, and labour (including herding, searching, guarding).
14. Medicinal, biochemical and genetic resources	Production of substances and materials derived from organisms (plants, animals, fungi, microbes) used for medicinal and veterinary purposes. This includes the production of genetic information used for plant and animal breeding and biotechnology.
15. Learning and inspiration	Nature provides opportunities for the development of the capacities that allow humans to prosper through education, acquisition of knowledge and development of skills. In general, this contributes to wellbeing, scientific knowledge, and inspiration for artistic and technological purposes.
16. Physical and psychological experiences	Nature offers opportunities for physically and psychologically beneficial activities. It includes activities related to leisure, tourism and enjoyment.
17. Supporting identities	Diverse components of the ecological environment are the basis for the development of a territory at different levels, as well as the grounds for religious, spiritual, and social-cohesion experiences. It also includes the opportunities offered by nature for people to develop a sense of place, purpose, belonging, and it is the basis for narratives and myths, rituals and celebrations (e.g., ***el reinado de la palma de cera*** in Salento, Quindío; or the ***Festival del cangrejo***, San Andrés).
18. Maintenance of options	The capacity of ecosystems, habitats, species or genotypes to keep human options open in order to support a later good quality of life: ▪ Benefits associated with the continued existence of a wide variety of species, populations and genotypes. ▪ Future benefits (or threats) derived from keeping options open for yet unknown discoveries and unanticipated uses of particular organisms or ecosystems that already exist (e.g. new medicines or materials). ▪ Future benefits (or threats) that may be anticipated from on-going biological evolution (e.g. adaptation to a warmer climate, to emergent diseases, development of resistance to antibiotics).

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