

Manual on the Basic Set of Environment Statistics of the FDES 2013



Geological and geographical information and Statistics

(Topic 1.1.3: of the Basic Set of Environment Statistics of the FDES 2013)

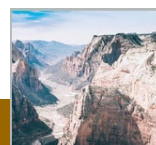
*Elaborated by the Environment Statistics Section
of the United Nations Statistics Division,
in collaboration with the
Expert Group on Environment Statistics*

**Version 3.0
16 August 2023**

Methodology sheet of the Basic Set of Environment Statistics of the FDES:

http://unstats.un.org/unsd/environment/FDES/Manual_BSES.htm

<http://unstats.un.org/unsd/environment/fdes.htm>



1. Acknowledgement

The Manual on the Basic Set of Environment Statistics consists of a series of methodology sheets for the collection or compilation of all environment statistics embedded in the FDES 2013. The work on the Manual of the Basic Set of Environment Statistics is being coordinated by UNSD and is being carried out in a collaborative way with the Expert Group on Environment Statistics (EGES) and other thematic experts from specialized agencies.

This methodology sheet offers methodological guidance including definitions, classifications, statistical methods for collection and/or compilation, dissemination and main uses of the sets of statistics on geological and geographical information and statistics. In addition, the sheet contains updates of terminology, definitions, tiers, references and classifications which will be taken into account in future revisions of the FDES 2013.

This methodology sheet was drafted by Francisco Javier Jimenez Nava (previously at INEGI, Mexico) with contributions from the EGES. The draft was further reviewed by Nelli Baghdasaryan (Statistical Committee of the Republic of Armenia), Maria Luisa Pimenta (Brazilian Institute of Geography and Statistics), Anjali De Abreu-Kisoensingh (General Bureau of Statistics, Suriname), Cecille Blake and Mark Iliffe (UNSD) and Ekaterina Poleshchuk (UNEP). The finalization and dissemination of the methodology sheet was undertaken by UNSD.

Contents

1.	Statistics in Topic 1.1.3: Geological and geographical information	4
2.	Introduction and relevance.....	5
3.	Definitions and description of the statistics	7
	3A. Definition of the statistics	9
4.	International sources and recommendations	14
	4A. Classifications and groupings	14
	4B. Reference to international statistical recommendations, frameworks and standards	16
	4C. Sources of global and regional statistics and indicators	17
5.	Data collection and sources of data.....	20
	5A. Sources of data.....	20
	5B. Data compilation (procedures and instruments) and transformation into environment statistics	22
6.	Uses and dissemination	24
	6A. Potential presentation and dissemination formats	24
	6B. SEEA accounts/tables that use these statistics	27
	6C. Commonly used indicators that incorporate these statistics	27
	6D. SDG indicators that incorporate these statistics.....	27

1. Statistics in Topic 1.1.3: Geological and geographical information

Code and location in the FDES 2013			
Component	Sub-Component	Topic	Code and Environment Statistic
1. Environmental Conditions and Quality	1.1 Physical Conditions	1.1.3. Geological and geographical information	a. Geological, geographical and geomorphological conditions of terrestrial areas and islands
			1. Length of border
			2. Area of country or region
			3. Number of islands
			4. Area of islands
			5. Main geomorphological characteristics of islands
			6. Spatial distribution of land relief
			7. Characteristics of landforms (e.g., plains, hills, plateaus, dunes, volcanoes, mountains, seamounts)
			8. Area by rock types
			9. Length of fault lines
			b. Coastal waters (including area of coral reefs and mangroves)
			c. Length of marine coastline
			d. Coastal area

2. Introduction and relevance

Statistics on geographic and geological characteristics of a country comprise most common and mostly static properties, such as border length, country area, relief and bedrocks. Although rare, any changes either caused by geologic processes or human actions affected these properties, can have big impacts on the population, for example: border changes, landslides and earthquakes. Even though, not obvious in official statistics, geology and its branches have traditionally been used to develop fundamental national data and information, including topographic maps, geographic names and geodetic networks of reference points. During the past centuries, this topographic, geographic and geodetic data has been instrumental for the development of most national and international infrastructures such as national cadastres (property registers), navigation activities, among others, and in recent decades also for monitoring sea-level rise.

The production and dissemination of proper statistics on geological and geographic topics was not common in the past, but it will become increasingly so, in view of global environmental changes, including climate change. Therefore, the accurate and standardized characterization of areas under risks, or already affected, need to be addressed in proper information channels and official statistics. In addition, the delimitation of geo-physical and administrative characteristics of countries' land and territorial waters serves as an input to the quantification and reporting of many other environmental topics, hence the quality and comparability of these data is also of critical importance in statistics.

The knowledge of the geological environment is an inexhaustible source of information about minerals, rocks, water and natural resources. Their interaction with endogenous and exogenous processes shapes the land where people live and perform their activities.

Contemporary research in geology is not based only on descriptive and classificatory reasoning, it has moved from the empirical towards more complex levels of knowledge, with explanatory reasoning (Engelhardt & Zimmermann, 1988).¹ Geological science also addresses phenomena that occur in the earth's crust and can cause human tragedies resulting from volcanic eruptions, earthquakes, tidal waves, etc. In other cases, geology has also made it possible to clarify some unknowns of the history of the planet and of life itself, an event possible thanks to the evidence inscribed on the rocks.

The theory of tectonic plates establishes that the earth's crust is made up of different plates that "float" on magma or molten rock. These plates are far from static, that is, they move in different directions, and in the process causing separation and collision between them. The science of tectonic plates is invaluable for explaining a series of terrestrial phenomena. For example, the theory explains the genesis of large mountain ranges (as a consequence of plate collisions) as well as oceanic ridges as a consequence of the separation of plates and the emergence of magma that solidifies in contact with water.

It is now known that the success of any engineering work can be assessed mainly by the degree to which the structure is adapted to the geological environment in which it is built, to the extent that more advanced studies tend to consider the rock, substrate and soil masses, as an integral part of the structure. The branches of engineering most

¹ Von Engelhardt, W. & Zimmermann, J. (1988) Theory of Earth Science. CUP Archive, 1988.

deeply affected by geological factors are mining, oil and civil engineering. While being obvious with respect to the first two, the application of geology is relatively recent in civil engineering and increasing in importance every day. Among the branches of geology that have application to the problems of civil engineering are physiography, hydrology, petrography, stratigraphy, structural geology and economic geology.

The field of sciences and disciplines which include the prefix 'geo' is very broad and diverse, therefore the scope of this methodology sheet is narrowed to address selected subjects from geology and geography: namely the physical characteristics of countries (mostly used in an international comparability context) such as land with area and boundaries and territorial waters; and also rather dynamic features such as coastlines and coastal areas. On the other hand, the related, but separate areas of statistics on land cover and land use, soils and mineral resources are covered in specific methodology sheets. In addition to the guidance materials provided under the umbrella of FDES², related aspects and more guidance is provided by UN GGIM³ and SEEA.⁴

² United Nations Statistics Division (2017) Framework for the Development of Environment Statistics (FDES 2013), <https://unstats.un.org/unsd/envstats/fdes.cshhtml> (accessed 16 August 2023)

³ United Nations Committee of Experts on Global Geospatial Information Management (UN GGIM), <https://ggim.un.org> (accessed 16 August 2023)

⁴ United Nations, European Commission, Food and Agriculture Organization of the United Nations, International Monetary Fund, Organisation for Economic Co-operation and Development and World Bank (2014) System of Environmental-Economic Accounting 2012: Central Framework. Studies in Methods, Series F, No. 109. Sales No. 12.XVII.12, <https://seea.un.org> (accessed 16 August 2023)

3. Definitions and description of the statistics

Topic 1.1.3: Geological and geographical information includes general geological and topographic information on the extent and characteristics of the country's territory and relief. These characteristics typically change slowly over time; as such, the statistics produced are normally static. Because of their nature, these geological (e.g., bedrock, fault lines and volcanoes) and geographical (e.g., territorial borders, area of country, elevation and length of marine coastline) data are often presented in map form. The main data sources are information systems operated by national geographical and geological institutions and authorities.⁵

The main statistical variables in this methodology sheet are the geological and geographical conditions of terrestrial and coastal areas and islands within a country and its maritime areas. The following generic definitions apply:

- Geology is the study of the rocks and physical processes of the earth in order to understand its origin and history.⁶ The science of geology has been divided into two major areas: physical and historical geology. Physical geology studies the materials that make up the earth and seeks to understand the different processes that act below and above the surface. Historical geology includes the origin of the Earth and its evolution over time.⁷ The following disciplines of geology are relevant:
 - Geomorphology is the scientific discipline concerned with the description and classification of the Earth's topographic features'.⁸
 - Geodesy is 'scientific discipline concerned with the precise figure of the Earth and its determination and significance. Until the advent of satellites, all geodesic work was based on land surveys made by triangulation methods employing a geodesic coordinate system (one used to study the geometry of curved surfaces)'.⁹
 - Relief is the shape of the earth's surface. High relief generally denotes large local differences in the height of the land; low relief indicates little variation in altitude.¹⁰
- Geography according to UNESCO, is a 'science that locates, describes and compares all the geographical phenomena that happen on Earth and the influence they cause on the life of man'. The following generic terms and specifications apply:
 - Territory: In the FDES when the term territory is used, it means the territory or area of reference, which can be a country, other administrative area below national level, or a natural area such as a watershed or river basin, depending on the context.
 - Toponymy or geographic names is the 'taxonomic study of place-names, based on etymological, historical, and geographical information'.

⁵ United Nations Statistics Division (2017) Framework for the Development of Environment Statistics (FDES 2013), <https://unstats.un.org/unsd/envstats/fdes.cshtml> (accessed 16 August 2023)

⁶ Cambridge dictionary, <https://dictionary.cambridge.org/dictionary/english/geology> (accessed 16 August 2023)

⁷ Tarbuck, E. J.; Lutgens, F. K., and Tasa, D. (2005) Earth sciences. Pearson Education S.A., Madrid, Spain.

⁸ Encyclopaedia Britanica, <https://www.britannica.com/science/geomorphology> (accessed 16 August 2023)

⁹ Encyclopaedia Britanica, <https://www.britannica.com/science/geodesy-science> (accessed 16 August 2023)

¹⁰ Oxford dictionary of Geography, <https://ia801908.us.archive.org/34/items/geography-encyclopedia/Oxford%20Dictionary%20of%20Geography.pdf> (accessed 16 August 2023)

- Geospatial Information - provides the digital and graphical connection between a geographic place, location, its people and their activities, and is used to illustrate what is happening – where, how and why.¹¹
- A National Spatial Data Infrastructure (NSDI) identifies technology, policies, standards, good practices, and human resources necessary to acquire, process, store, disseminate, and analyse the use of geospatial information.¹²

More related or relevant terms can be consulted in the Global Statistical Geospatial Framework: Implementation Guide (<https://unstats.un.org/unsd/statcom/53rd-session/documents/BG-3x-EG-ISGI-GSGF-Implementation-Guide-E.pdf>) and Glossary of Terms for the Standardization of Geographical Names (https://unstats.un.org/unsd/ungegn/pubs/documents/Glossary_of_terms_rev.pdf).

The next section introduces definitions and clarifying remarks for each of the individual statistics included in this topic.

¹¹ The Global Statistical Geospatial Framework: Implementation Guide, <https://unstats.un.org/unsd/statcom/53rd-session/documents/BG-3x-EG-ISGI-GSGF-Implementation-Guide-E.pdf> (accessed 16 August 2023)

¹² The Global Statistical Geospatial Framework: Implementation Guide, <https://unstats.un.org/unsd/statcom/53rd-session/documents/BG-3x-EG-ISGI-GSGF-Implementation-Guide-E.pdf> (accessed 16 August 2023)

3.A Definition of the statistics

Statistical definitions and related clarifications are introduced in this section, since not all of the relevant variables in this topic can be strictly defined as a statistic.

Topic 1.1.3 Geological and geographical information

The following topics include descriptive information and statistics on the relatively permanent land characteristics of a country, and the relatively more dynamic changes of coastal areas characteristics.

1.1.3.a. Geological, geographical and geomorphological conditions of terrestrial areas and islands.

1.1.3.a.1 Length of border

Length of border is defined as the border line that divides two countries. Total length of the country border and length of segments bordering other countries or entities are relevant. Border or boundary concept is defined as a line marking the limits of a unit of land, often a geographical region, but also of economies or societies.¹³

Remarks:

1. This information may be obtained from data or maps in official national/international sources.
2. National borders are delimited in accordance with national and international organizations legal backing.
3. Statistical information of the length of the border, can be represented by geographical location of border, total length as well as length of separate bordering entities, e.g. countries.

1.1.3.a.2 Area of country or region

An area of land that forms an independent political unit with its own government.¹⁴

Related definitions:

1. **Land area** is a country's total area, excluding area under inland water bodies, national claims to continental shelf, and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.¹⁵
2. **Total surface area** refers to the total area of the country which comprises land area and inland waters.¹⁶

Remarks:

1. Statistical information of the area of a country can be represented in different measures, by entity or geographical location.

¹³ Oxford dictionary of Geography, <https://ia801908.us.archive.org/34/items/geography-encyclopedia/Oxford%20Dictionary%20of%20Geography.pdf> (accessed 16 August 2023)

¹⁴ Cambridge dictionary, <https://dictionary.cambridge.org/us/dictionary/english/country> (accessed 16 August 2023)

¹⁵ The World Bank, data, <https://data.worldbank.org/indicator/AG.LND.TOTL.K2> (accessed 16 August 2023)

¹⁶ UNSD, Environmental Indicators, <https://unstats.un.org/unsd/environment/totalarea.htm> (accessed 16 August 2023)

1.1.3.a.3 Number of islands

Number of islands of an island group or island state.

1.1.3.a.4 Area of islands

Surface area of the island, island group, or island state in square kilometres.

1.1.3.a.5 Main geomorphological characteristics of islands

According to morphological characteristics, three generic terms can be defined:

- **Island:** Any area of land smaller than a continent and entirely surrounded by water. Islands may occur in oceans, seas, lakes, or rivers. A group of islands is called an archipelago. Islands may be classified as either continental or oceanic. Oceanic islands are those that rise to the surface from the floors of the ocean basins. Continental islands are simply unsubmerged parts of the continental shelf that are entirely surrounded by water.¹⁷
- **Reef:** A mass of rock or coral (coral reef) which either reaches close to the sea surface or is exposed at low tide and may constitute a hazard to surface navigation.
- **Cay:** A small, low island, usually sandy, situated on a coral reef platform. Sand cays are usually formed on the edge of the coral platform, opposite the direction from which the prevailing winds blow. A cay is often elongated perpendicular to the prevailing winds, but its shape may change considerably with deposition in calm weather and erosion during storms. Even fairly large cays are vulnerable to complete destruction by severe hurricanes or typhoons.

1.1.3.a.6 Spatial distribution of land relief

According to the European Environment Information and Observation Network (EIONET)¹⁸, relief is the physical shape, configuration or general unevenness of a part of the Earth's surface, considered with reference to variation of height and slope or to irregularities of the land surface; the elevation or difference in elevation, considered collectively, of a land surface.

1.1.3.a.7 Characteristics of landforms

A landform is defined as any physical feature of the Earth's surface having a characteristic, recognizable shape and produced by natural causes. Countries may have nationally defined landform descriptions and classifications, depending on their particular characteristics.

Typical landforms are mountain slopes and valleys, plateaus, flood-plains, streams, beach, dunes, estuaries, etc. These may be presented in statistical tables with their total area, and where relevant changes or other characteristics.

Landforms are shaped as consequence of tectonic plates movements or external modelling agents as the rain, wind and waves of the sea.

Explanatory notes:

¹⁷ Encyclopedia Britannica, <https://www.britannica.com/science/island> (accessed 16 August 2023)

¹⁸ European Environment Information and Observation Network (EIONET), <https://www.eionet.europa.eu/> (accessed 16 August 2023)

- Abyssal plain: Any terrain portion with a flat surface or with mild undulations. Flat region, with smooth slope or almost horizontal of the bottom of the sea.¹⁹
- Plateau: An extensive and relatively flat upland. Some are formed structurally, from resistant and horizontal rocks, or from the outpouring of plateau lavas; others are erosion surfaces.²⁰
- Dune: A hill or ridge of sand accumulated and sorted by wind action. Once a dune is formed, sand will settle on it rather than on bare surfaces. This is because the friction of the sandy surface is enough to slow down the wind, which then sheds some of its load.²¹
- Volcanoes: An opening in the crust out of which magma, ash, and gases erupt. The shape of the volcano depends very much on the type of lava. Cone volcanoes are associated with thick lava and much ash. Shield volcanoes are formed when less thick lava wells up and spreads over a large area, creating a wide, gently sloping landform. Most volcanoes are located at destructive or constructive plate margins.²²
- Mountain: landform that rises prominently above its surroundings, generally exhibiting steep slopes, a relatively confined summit area, and considerable local relief. Mountains generally are understood to be larger than hills, but the term has no standardized geological meaning.²³

1.1.3.a.8 Area by rock types

This statistic refers to an occupied surface for a rocky material type, not including those that are covered by urban infrastructure and water bodies. While not commonly reported in official statistics, this statistic is an important input for developing other environmental and integrated assessments, including for defining areas under risks of natural disasters, such as landslides; also, for defining ecosystem types/units for the purposes of SEEA Ecosystem Accounting (SEEA-EA).²⁴

Explanatory notes:

1. The following rock types can be distinguished:
 - Igneous rocks: rock resulting from the solidification of melting rock or magma.
 - Sedimentary rock is formed (by the accumulation of sediment in water or from the air).
 - Metamorphic rock is a rock that has undergone chemical or structural changes produced by increase in heat or pressure, or by replacement of elements by hot, chemically active fluids.
 - There are further subtypes for each of the three rock types mentioned above.

1.1.3.a.9 Length of fault lines

¹⁹ Encyclopedia Britannica, <https://www.britannica.com/science/abyssal-plain> (accessed 16 August 2023)

²⁰ Oxford Dictionary of Geography, <https://ia801908.us.archive.org/34/items/geography-encyclopedia/Oxford%20Dictionary%20of%20Geography.pdf> (accessed 16 August 2023)

²¹ ibid

²² ibid

²³ Encyclopedia Britannica, <https://www.britannica.com/science/mountain-landform> (accessed 16 August 2023)

²⁴ UN SEEA Ecosystem Accounting, https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_white_cover_final.pdf (accessed 16 August 2023)

A fault is a fracture or zone of fractures between two blocks of rock. Faults allow the blocks to move relative to each other. This movement may occur rapidly, in the form of an earthquake - or may occur slowly, in the form of a creep. The fault surface can be horizontal or vertical or some arbitrary.²⁵

Explanatory notes:

- Normal fault: a dip-slip fault in which the block above the fault has moved downward relative to the block below. This type of faulting occurs in response to extension efforts and along oceanic ridge systems.
- Reverse fault: thrust fault - a dip-slip fault in which the upper block, above the fault plane, moves up and over the lower block. This type of faulting is common in areas of compression, such as regions where one plate is being subducted under another.
- Strike-slip fault: a fault on which the two blocks slide past one another.
- A left-lateral strike-slip fault is one on which the displacement of the far block is to the left when viewed from either side.
- A right-lateral strike-slip fault is one on which the displacement of the far block is to the right when viewed from either side.

1.1.3.b. Coastal waters (including area of coral reefs and mangroves)

Statistics on coastal waters, coastlines and coastal areas are relevant and highly demanded in the context of many existing and emerging policies often defined as Integrated Coastal Zone Management. Many relevant guidelines with technical definitions can be explored, for example from Barcelona Convention and Mediterranean Action Plan²⁶; first UN Ocean Conference 2017.²⁷

As the interface between terrestrial environments and open oceans, coastal waters encompass many unique habitats and serve important human needs. Coastal habitats include estuaries, coastal wetlands, seagrass meadows, coral reefs, mangroves, kelp forests, and upwelling areas. They also provide habitat for many other organisms such as marine mammals, corals, sea turtles, and submerged aquatic vegetation. Coastal waters support a wide range of human activities such as tourism, recreation, transportation, and fisheries. Lands on the coast are highly desirable places for people to live.²⁸

Coral reefs are one of the most diverse ecosystems on earth. They support fisheries, and an estimated one billion people have some dependence on coral reefs for food and income from fishing and tourism. They also protect shorelines and create land by dissipating wave energy and continue to be a potential source of new medicines. Yet coral reefs are threatened by a combination of impacts that include ocean warming and acidification, as well as local pollution, overfishing and sedimentation.

Artificial reefs are submerged (or partly exposed to tides) structures deliberately placed on the seabed to mimic some functions of a natural reef, such as protecting, regenerating, concentrating and/or enhancing populations of living marine resources. This includes the protection and regeneration of habitats. The reefs serve as habitat that functions as part of the natural ecosystem while doing no harm.²⁹

²⁵ USGS, https://www.usgs.gov/faqs/what-a-fault-and-what-are-different-types?qt-news_science_products=0#qt-news_science_products (accessed 16 August 2023)

²⁶ Barcelona Convention and Mediterranean Action Plan, <https://www.unep.org/uneppmap/> (accessed 16 August 2023)

²⁷ Ocean Conference, <https://oceanconference.un.org/> (accessed 16 August 2023)

²⁸ EPA. Coastal Water, <https://www.epa.gov/report-environment/coastal-waters> (accessed 16 August 2023)

²⁹ FAO, <http://www.fao.org/3/a-ax815e.pdf> (accessed 16 August 2023)

Mangroves are the characteristic littoral plant formations of tropical and subtropical sheltered coastlines. They are variously described as coastal woodland, tidal forest and mangrove forest. Generally, mangroves are trees and shrubs growing below the high-water level of spring tides. Their root systems are thus regularly inundated with saline water, even though it may be diluted due to freshwater surface run-offs and only flooded once or twice a year.³⁰

1.1.3.c. Length of marine coastline

Coastline is not a uniformly defined concept, because of complexities such as fractal dimensions. Coast is generally defined as 'broad area of land that borders the sea'.³¹ Coastal countries may have more specific definitions and official estimates of its length. Because of the many natural and engineering construction impacts affecting the coastline, its length and shape can vary substantially from one point in time to another.

1.1.3.d. Coastal area

Coastal areas are commonly defined as the interface or transition areas between land and sea, including large inland lakes. Coastal areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. Unlike watersheds, there are no exact natural boundaries that unambiguously delineate coastal areas.

Related terms:

Territorial sea: According to Part II, Articles 2 and 3 of the United Nations Convention on the Law of the Sea, the territorial sea is a marine space where a coastal State extends its sovereignty, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea. And every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Convention.³²

Exclusive Economic Zone: According to Article 55 of the United Nations Convention on the Law of the Sea, the exclusive economic zone is an area beyond and adjacent to the territorial sea, subject to the specific legal regime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention.

³⁰ FAO, <http://www.fao.org/forestry/mangrove/en/> (accessed 16 August 2023)

³¹ Encyclopedia Britannica, <https://www.britannica.com/science/coast> (accessed 16 August 2023)

³² UN, http://www.un.org/depts/los/convention_agreements/texts/unclos/convemar_es.pdf (accessed 16 August 2023)

4. International sources and recommendations

4A. Classifications and groupings

There are a few commonly applicable classifications on geological and geographical information, since the area is novel in the context of official statistics.

Geographical Classifications

Geographical classifications are a method to group geographies according to objective criteria. The Global Statistical Geospatial Framework considers two main classifications, Administrative and Gridded Geographies respectively, from which other geographies are derived. The resulting geographies are characterised by how they are geographically represented.

Standard country or area codes for statistical use (M49)

UNSD has developed the UN M49 as the Standard Country or Area Codes for Statistical Use.³³ The list of countries or areas in M49 includes those countries or areas for which statistical data are compiled by the Statistics Division of the United Nations Secretariat. The names of countries or areas refer to their short form used in day-to-day operations of the United Nations and not necessarily to their official name as used in formal documents. These names are based on the United Nations Terminology Database (UNTERM).

Geographic regions

Based on the M49 coding, UNSD has developed a geographic regions scheme which groups 249 countries and territories in the world into six regional, 17 subregional, and nine sub-subregional groups.

Geographic names

United Nations Group of Experts on Geographical Names (UNGEGN)³⁴ is one of the nine standing expert bodies of ECOSOC, has a long and rich history, beginning in 1967, of leading national geographical names standardization in jurisdictions around the world. UNGEGN functions through a bureau, nine working groups, two task teams and 24 geographical/linguistic divisions, currently implementing its Strategic Plan and Programme of Work 2021-2029 which covers the areas of training and capacity development, geographical names data management, romanization systems, terminology, publicity and funding, exonyms and toponymic guidelines. The vision is for every country to have a fully functioning and globally-aligned structure and policy framework, based on common principles for national standardization of authorized geographical names that identify location and respect the associated culture and heritage, and to have these names easily accessible for national and international use - facilitating consistent worldwide use of geographical names to foster communication and cooperation.

³³ Standard country or area codes for statistical use (M49), <https://unstats.un.org/unsd/methodology/m49/> (accessed 16 August 2023)

³⁴ United Nations Group of Experts on Geographical Names (UNGEGN), <http://unstats.un.org/unsd/geoinfo/geonames/> (accessed 16 August 2023)

With the wide dissemination of the nationally standardized forms through gazetteers, atlases, web-based data bases, toponymic guidelines, etc., UNGEGN promotes the use of these names internationally. At the global level, the group has produced a manual³⁵ for the standardization of the geographical names nationally, which provides certainty of the sources to be consulted in geographical names matters.

Classifications of Biomes

A biome is “...a biotic community finding its expression at large geographic scales, shaped by climatic factors, and perhaps better characterized by physiognomy and functional aspects [of vegetation], rather than by species or life-form composition. Biomes are frequently used as tools to provide large-scale (regional to global) backgrounds in a range of ecological and biogeographical studies.” (Mucina, 2019).³⁶ Biomes are the largest geographical biotic communities that are convenient to recognize. Most of them broadly correspond with climatic regions (zonobiomes), although other environmental controls are sometimes important, e.g., soils (pedobiomes) or topography (orobiomes).³⁷

There is no single authoritative list of biomes. While some biomes are recognized by all authors (e.g., tropical rainforest, taiga) many different biomes are proposed for less well-defined ecosystems, especially those on ecotones, such as savannas and woodland. For SEEA purposes, the IUCN GET list of biomes is used as a reference.³⁸

Classifications of ecoregions and biogeographic regions

An ecoregion is “A geographic group of landscape mosaics,” “resulting from large-scale predictable patterns of solar radiation and moisture, which in turn, affect the kinds of local ecosystems and animals and plants found there (Bailey, 2014).³⁹ Terrestrial ecoregions are often grouped into higher order biogeographic regions, where the different biogeographic regions (e.g., Nearctic for North America, Indomalaya for India and South-East Asia, etc.) reflect global differences in species distributions due to geographic separation and evolutionary history. On a smaller scale, ecoregions may be spatially contiguous units of a single biome, or subdivisions thereof, e.g., “West Siberian Taiga” and “East Siberian Taiga”.⁴⁰

Classification of fault lines

Rocks are result of tectonic events and respond in a fragile or ductile manner, meaning that their continuity is broken as a homogeneous body by the pressure of confinement in depth of the earth's crust. The behaviour of the rocks changes gradually from fragile to ductile.

A fragile structure is considered a discontinuity in the rock in which there is an opening and displacement.

³⁵ https://unstats.un.org/unsd/publication/seriesm/seriesm_88e.pdf (accessed 16 August 2023)

³⁶ Mucina, L. (2019). Biome: evolution of a crucial ecological and biogeographical concept. *New Phytologist*, 222(1), 97–114. <https://doi.org/10.1111/nph.15609> (accessed 16 August 2023)

³⁷ SEEA Ecosystem Accounting, https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_white_cover_final.pdf (accessed 16 August 2023)

³⁸ *ibid*

³⁹ Bailey, R. G. (2014). Ecoregions. In *Ecoregions: The Ecosystem Geography of the Oceans and Continents*. Springer New York. <https://doi.org/10.1007/978-1-4939-0524-9> (accessed 16 August 2023)

⁴⁰ SEEA Ecosystem Accounting, https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_white_cover_final.pdf (accessed 16 August 2023)

Explanatory notes:

1. Normal failure, when the blocks of a rock mass move, one downwards with respect to the other. The surface on which the movement occurs (fault plane), indicates the relative direction of the movement and is from vertical to inclined.
2. Reverse failure, when one of the blocks moves in an ascending way, with respect to the other along the fault plane, which tends to have a low inclination ($< 45^\circ$), it is classified as thrusts "if the inclination is less than 10° they obtain the name of landslides, when the displacement is usually of great magnitude.
3. Lateral failure (of heading), the movement manifests horizontal displacements that cause the lateral sliding of one block with respect to the other, the plane of failure is usually close to the vertical. Depending on the direction of this displacement, we can distinguish the dextral tear, in which, situating ourselves on one of the blocks, we would see the other moving towards our right, and the sinistral, the movement is opposite to the previous one. They are also called transverse failures.
4. Fracture separation of a land surface, without relative displacement of the blocks, on both sides of the plane of the fracture.

A ductile structure is considered a folded rock surface in which wavy shapes are distinguished.

Explanatory notes:

1. Anticline structure in which both sides are inclined in different directions, the layers of the rocks are inclined on both sides and on the inside (core) are the oldest units.
2. Syncline structure in which both sides are inclined in different directions, the rock layers are inclined towards the centre of the structure and in the core the most recent layers emerge.

4B. Reference to international statistical recommendations, frameworks and standards

The following international and national sources provide statistical recommendations and guidance for the production of geological and geographic information statistics and for compiling environment indicators.

- UN-GGIM⁴¹
- UNESCO⁴²
- UN, Oceans and the Law of the Sea⁴³
- USGS, United States Geological Survey⁴⁴
- GFGS, Global Forum for Geography and Statistics⁴⁵

⁴¹ UN GGIM, <https://ggim.un.org/> (accessed 16 August 2023)

⁴² UNESCO, <https://en.unesco.org/> (accessed 16 August 2023)

⁴³ UN Division for Ocean Affairs and Law of the Sea, <https://www.un.org/depts/los/index.htm> (accessed 16 August 2023)

⁴⁴ USGS, <https://www.usgs.gov/> (accessed 16 August 2023)

⁴⁵ GFGS, <https://www.efgs.info/about-efgs/global-forum-for-geography-and-statistics/> (accessed 16 August 2023)

- UGI, International Geographic Union⁴⁶
- IGS, International Geoscience Services⁴⁷
- BGS, British Geological Survey⁴⁸

The International Organization for Standardization (ISO) has developed a series of standards and technical specifications on Geographic information and Geomatics.⁴⁹ Multiple areas are covered, among which:

- ISO 19101-1:2014, Geographic information — Reference model — Part 1: Fundamentals
- ISO 19104:2016, Geographic information — Terminology
- ISO 19112:2019, Geographic information — Spatial referencing by geographic identifiers
- ISO 19115-1:2014, Geographic information — Metadata — Part 1: Fundamentals.

4C. Sources of global and regional statistics and indicators

A global source of geospatial information is the United Nations Maps & Geospatial services.⁵⁰

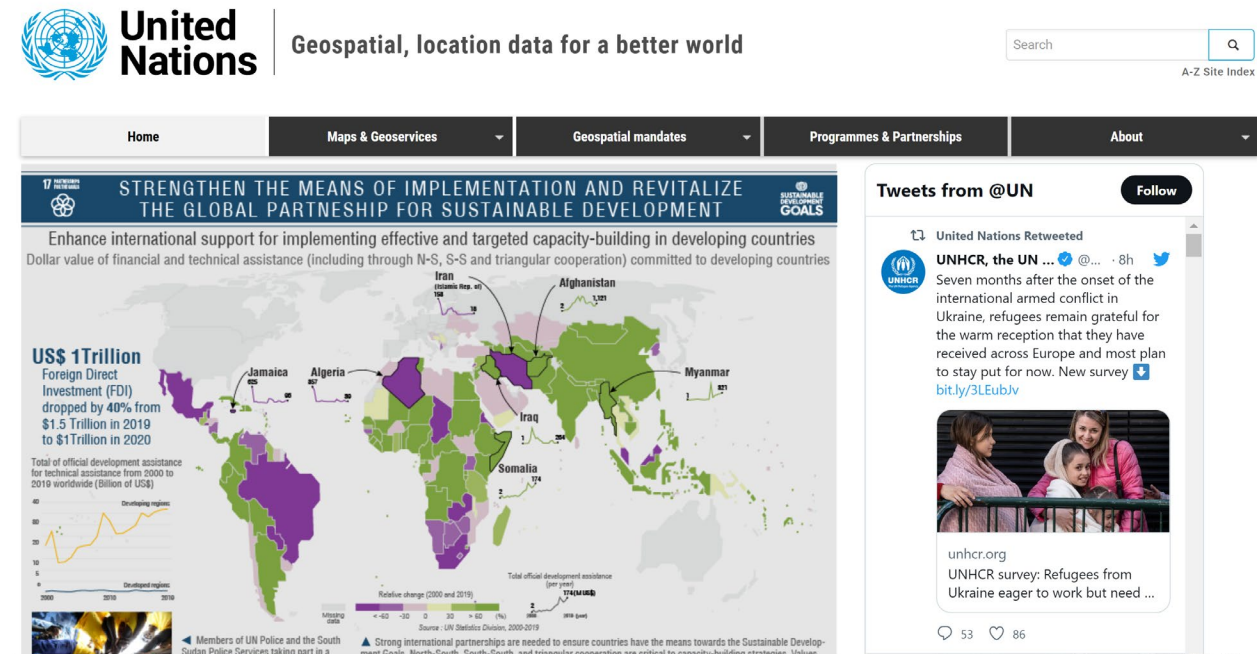


Figure 1: UN Maps & Geospatial services

⁴⁶ UGI, <https://igu-online.org/> (accessed 16 August 2023)

⁴⁷ IGS, <https://www.igsint.com/> (accessed 16 August 2023)

⁴⁸ BGS, <https://www.bgs.ac.uk/> (accessed 16 August 2023)

⁴⁹ International Organization for Standardization (ISO), <https://www.iso.org/committee/54904/x/catalogue/#:~:text=ISO%20%2D%20ISO%2FTC%20211%20%2D%20Geographic%20information%2FGeomatics> (accessed 16 August 2023)

⁵⁰ United Nations Maps & Geospatial services, <https://www.un.org/geospatial/mapsgeo> (accessed 16 August 2023)

Another international source is the Global Forum on Geography and Statistics (GFGS), which joins national statistics institutes, geographic agencies and research & development institutes into a global network.⁵¹

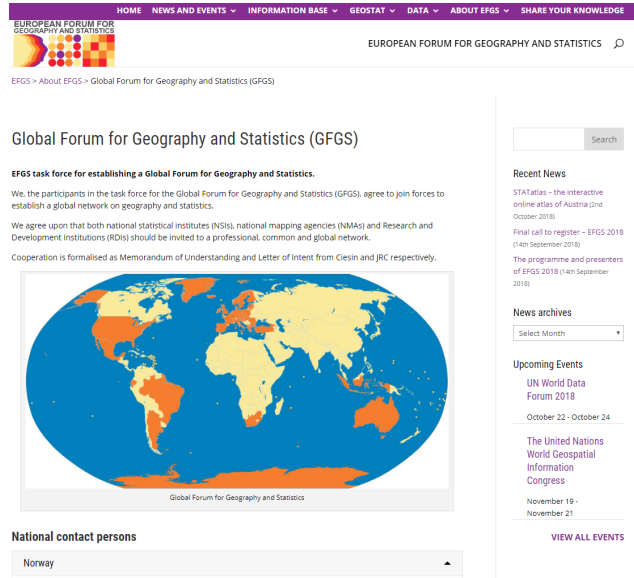


Figure 3: Global Forum on Geography and Statistics

Among some examples of information in the geological domain there are several sources of data that can be consulted at a global level, one of which is the European Geological Data Infrastructure (EGDI) providing access to geological datasets of geological survey organizations in Europe. This source of information can be consulted both by the general public and specialized users to exploit the entire database available in a map viewer.⁵²



Figure 4: European geological data infrastructure

⁵¹ GFGS Global Forum for Geography and Statistics, <https://www.efgs.info/about-efgs/global-forum-for-geography-and-statistics/> (accessed 16 August 2023)

⁵² EGDI, European Geological Data Infrastructure, <http://www.europe-geology.eu/> (accessed 16 August 2023)

One of the most relevant initiatives is the Commission of the Geological Map of the World (CGMW).⁵³ It has been responsible for publishing geological data at small scales: including tectonic maps, mineral deposits, natural resources, etc. It also plans to have a leading role in the development of international standards. The CGMW actively participates in the One Geology initiative.

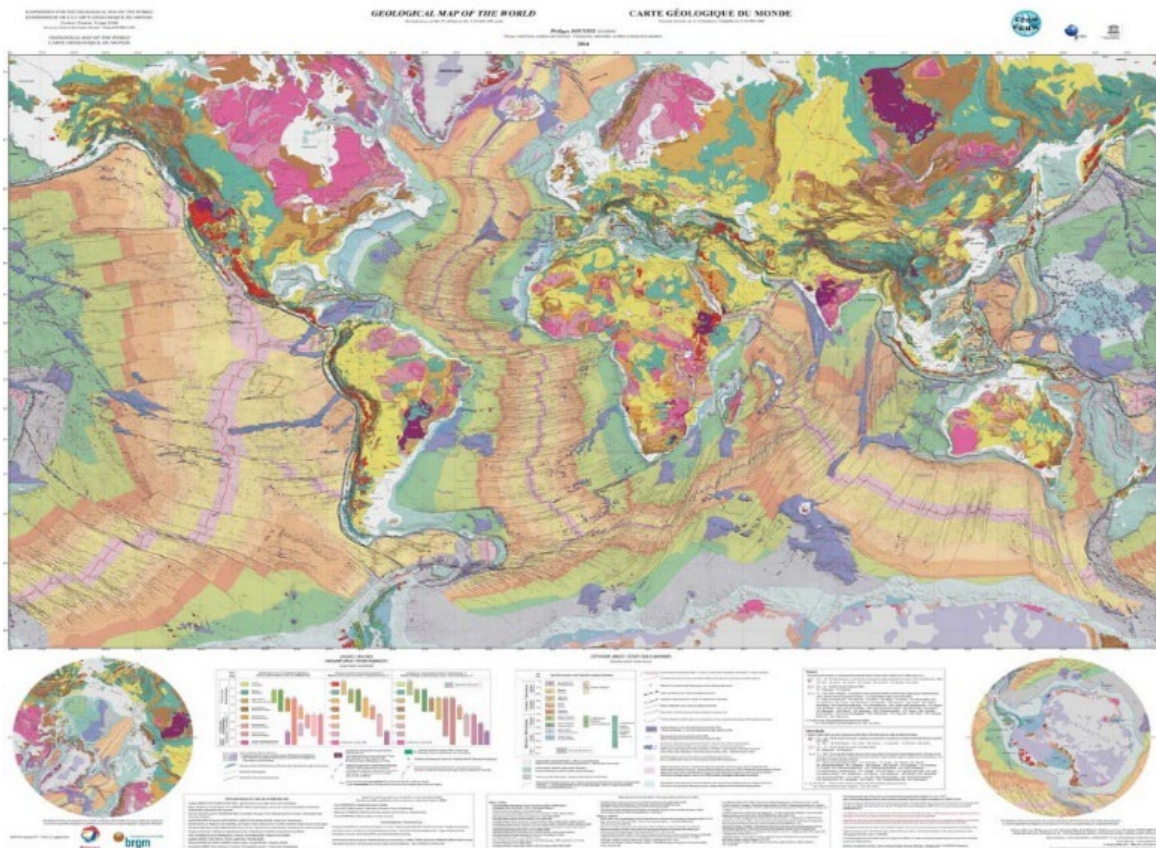


Figure 5: Geological map of the world

⁵³ CCGM Commission for the Geological Map of the World, <https://cgmw.org/en/home/164-carte-geologique-du-monde-a-l-echelle-de-135-000-000-9782917310243.html> (accessed 16 August 2023)

5. Data collection and sources of data

This section introduces examples of international and national data sources and describes the procedures necessary to transform geographic and geological data collected at national level into series of environment statistics.

5A. Sources of data

This section identifies international and national sources and types of data collection for each group of statistics related with geological and geographical conditions of terrestrial areas and islands.

In an international context, the UN Standard of Country names and area codes for statistical use (M49)⁵⁴ is relevant. Besides the official country names and codes, it includes also macro-geographic regions denominations. These names are based on the United Nations Terminology Database (UNTERM).⁵⁵ The wide range of geological and geographical statistics contained in this methodology sheet originates from sources of primary national data including geological and geographical institutions, universities and research institutes. These institutional partners generally collaborate to produce information and statistics on many related topics, such as boundaries and areas of administrative entities, land forms, rocks, etc. In case a country wishes to consult international data sources, it is advisable to consider global statistics and existing UN sources.

The types of sources by which the basic data of the statistics contained in this methodology sheet are collected include:

- Remote sensing products (for example: on identification of minerals and rocks; geological structures and their changes/impacts, such as landslides);
- Thematic maps (types of bedrocks and their history, topographic maps);
- Surveys (including geodetic data). Different types of surveys, including the census survey, geodetic, cadastral and topographic survey apply different approaches/methodologies and data types. Also field work is done to collect and verify geographical names;
- Scientific research.

Typically, most countries have a national agency engaged in fundamental geographic and geodetic data production, such as topographic maps, geographic names and geodetic references. This data supports multitude of activities among which maintaining cadastral registers, civil engineering and navigation. Historically such data were produced by, or in cooperation with military authorities. Therefore, in view of developing statistical time-series, data may be sought from such agencies and related research institutes. Examples of national activities in several countries are listed below:

- In Mexico, geodetic activities at INEGI⁵⁶, part of national spatial data infrastructure (IDEMEX) include topographic and cadastral mapping, delimitation of the exclusive economic zone; surveys to determine greater density of accurate geographic positioning stations (with GPS coordinates), development of a new Geodetic Reference System, geodetic standards and related information services.

⁵⁴ Country names and area codes for statistical use (M49), <https://unstats.un.org/unsd/methodology/m49/> (accessed 16 August 2023)

⁵⁵ UNTERM website, <http://unterm.un.org> (accessed 16 August 2023)

⁵⁶ Publication by Hansen-Albites, F-A. 2005. Geodesy as a Fundamental Data Set in the Mexican SDI (IDEMEX). Online: https://www.fig.net/resources/proceedings/fig_proceedings/cairo/papers/ts_13/ts13_03_hansen.pdf (accessed 16 August 2023)

- The UK has a number of dedicated institutions, including the Space Geodesy Facility (<http://sgf.rgo.ac.uk>) managed by the British Geological Survey (www.bgs.ac.uk); National Oceanography Centre (<http://noc.ac.uk>) with a Permanent Service for Mean Sea Level (PSMSL, <http://www.psmsl.org>); Ordnance Survey of Great Britain (www.ordnancesurvey.co.uk). Key activities include contributions to global satellite navigation, monitoring of gravity, plates tectonics / deformations and sea-level rise.
- In October 2022, the Republic of Armenia government agreed on a draft decision "On approving the list of basic and thematic spatial data and their standardization guidelines in the national spatial data infrastructure in the Republic of Armenia". All governing bodies will provide and, at the same time, have access to an integrated geodatabase. The maps will be publicly available on the official website of the cadastre (<https://www.e-cadastre.am/en>).

As the institutions that produce primary geological data and the type of sources vary according to the specific geological statistics of FDES, the following table 1 presents the types of sources and main institutional participants by subject of environment statistics at the national level.

Table 1. Geological and geographical statistics, institutional participants and types of sources used by INEGI in Mexico.

FDES Topic	Environment statistics	Type of data source	Institutional source
1.1.3 Geological and geographical information	a. Geological, geographical and geomorphological conditions of terrestrial areas and islands.	Remote sensing, thematic maps, scientific research and administrative records.	Government institutes/National geological/Statistics Office/Universities, research agencies and other organizations both national and international.
	b. Coastal water (Including area of coral reefs and mangroves).	Remote Sensors, Thematic Maps and Scientific research.	International organizations/government institutes/National Forest/universities/ research agencies and other organizations.
	c. Length of marine coastline.	Remote sensing, thematic maps, Scientific research.	Government institutes/Universities, research agencies and other organizations.
	d. Coastal area.	Remote sensing, thematic maps, Scientific research.	Government institutes/Universities, research agencies and other organizations.

Source: INEGI

Many countries build geological and geographical inventories but due to limited resources, they usually do it at infrequent intervals. Geology of an area does not change unless there has been significant human interference – mining / explosion or some form of seismic or climatic activity. On the other hand, facilitating access to remote sensing data has allowed recent assessments of the geological and geographical cover. As mentioned above, in

countries with limited resources, it would facilitate the inventories and produce data on geological coverage every 10 years and in some countries even less frequently.

On the other hand, in the absence of geological and geographical inventories, countries may depend on estimation procedures to determine for example the extent of the rocks, based on expert knowledge and observation, which could also be with the help of field validation, sample or specific aerial photography.

Ideally, the geological and geographical primary data is produced with a national level coverage. But sometimes in remote sensing-based inventories or interpretations, they can produce data with partial national coverage, particularly for very large countries. In this case, the data may be available only for parts of the country area at any given time.

Statistical Unit

The statistical unit for geological and geographical data from remote sensing is the area covered by country, islands, landform, rocks, coral reefs and coastal areas, typically reported in square kilometres.

5B. Data compilation (procedures and instruments) and transformation into environment statistics

The construction of time series of statistical information of geological and geographic data on the above topics is relevant for the ones that are subject to relatively frequent changes, such as coastal areas and sea-level rise. On the other hand, most of the topics comprise relatively permanent land structures and delimitations, which if not meaningful as statistical time series, are still needed as underlying data input to the quantification of other environment statistics. Such underlying data can be generated using observation points in the field in order to define the characteristics of continental elements such as marine, main types of bedrocks, deposits and linear structures, such as faults affecting the ground. This information is often needed prior to establishing monitoring networks.

Where relevant, producing time series is not simple, since in most countries the primary data are scarce in terms of observation points that cover the continuum of time and space. Most likely, very detailed series can be added to the relevant variables sought to produce the statistical time series on topics such as coastal erosion and accretion. The environmental statistician will compile, validate, describe and structure these data points and produce statistical series for dissemination.

Data quality and validation

The quality of the data of the geological and geographical inventories should be evaluated taking into account criteria such as the methodologies used, as well as the analysis of the comparability between different inventories produced at specific times or periods and / or covering different territories, as necessary. In addition, the quality of the data from remote sensing should be evaluated taking into account criteria such as image interpretation procedures and validation processes involving field sampling or field verification.

Spatial considerations should take into account the spatial coverage of inventories over time for the assessment of comparability, as they may not cover the entire national and / or relevant territory, often due to insufficient resources.

Aggregation and disaggregation

If basic data on island, continental relief, rock, mangrove and coastal areas are produced by remote sensing these series can generally be aggregated nationally and disaggregated by region. A possible breakdown of the statistical series relevant to the rocky area by subtype, for example, in sedimentary rocks is classic or calcareous.

Transformation into environment statistics series

The situation of each country is very unique in terms of data availability and periodicity of the production of primary data around geological and geographical statistics. However, the following considerations could be useful since they synthesize the general attributes of the most important and common environment statistics in the FDES.

Table 2: Main considerations for transforming the primary geological and geographical data into some examples of statistics, based on the experience of Mexico.

FDES Topic	Environment Statistic	Category of Measurement	Unit of measure	Recommended periodicity	Potential aggregations and disaggregations
1.1.3	Main geomorphological characteristics of islands	Area	Square Kilometres (Km ²) and percentage (%)	Five years	By marina, political division.
1.1.3	Characteristics of plain landforms	Area	Square Kilometer (Km ²) and percentage (%)	Five years	By type, coastal plain, erosion plain, eolian plain, delta plain, alluvial plain.
1.1.3	Characteristics of plateau landforms	Area	Square Kilometer (Km ²) and percentage (%)	Five years	By volcanic plateau
1.1.3	Characteristics of dune landforms	Area	Square Kilometer (Km ²) and percentage (%)	Five years	By type frontal dunes, hollow dunes, parabolic dunes, barjan dunes, transgressive dunes, fossil dunes.
1.1.3	Characteristics of volcanic landforms	---	----	Ten years	By assets or inactive.
1.1.3	Area by rock types	Area	Square Kilometer (Km ²) and percentage (%)	Ten years	By type of rock, geological age and distribution.
1.1.3	Fault lines	Length	Kilometer (Km)	Two years	By type normal fault, reverse and slip.

Source: INEGI

6. Uses and dissemination

6A. Potential presentation and dissemination formats

This section presents examples of countries and international organizations to show how geological and geographical statistics and indicators can be disseminated. Examples of tables, graphs and maps of selected countries and regions are included.

Tables and charts

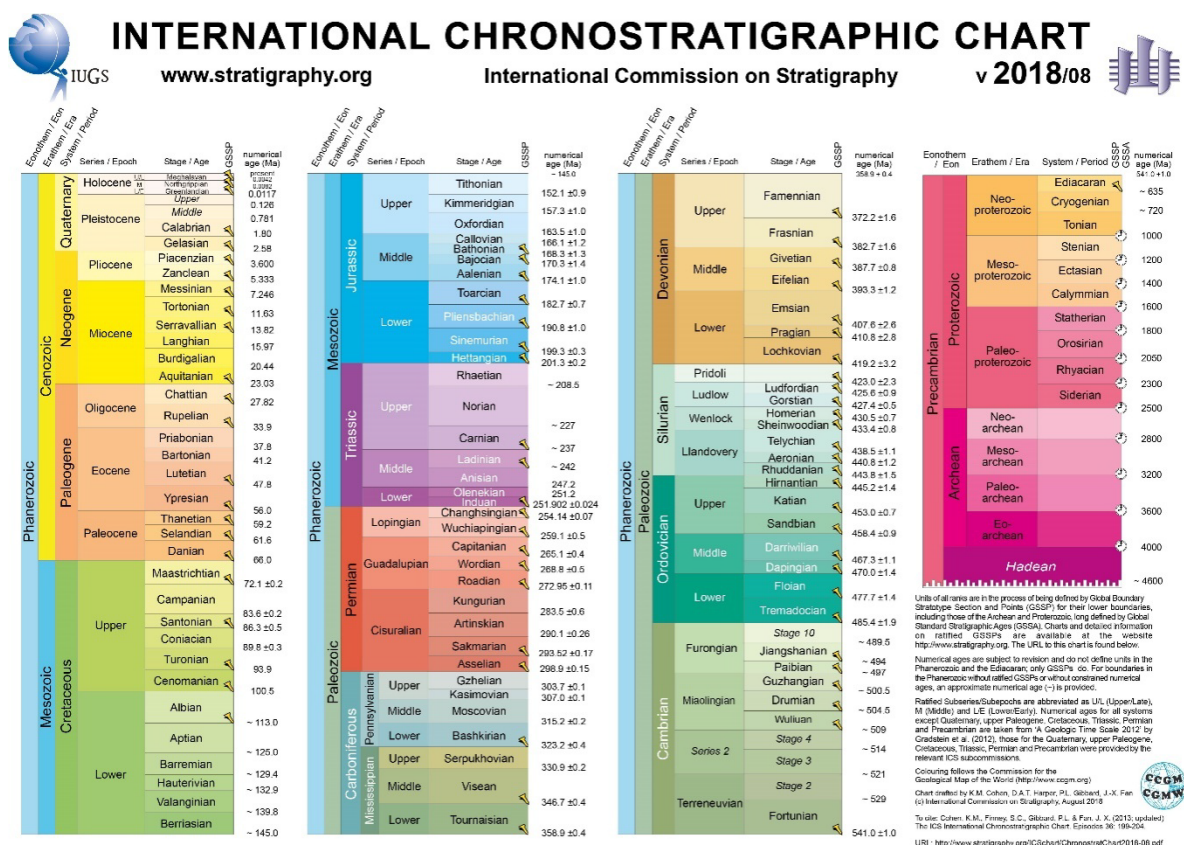


Figure 6: International chronostratigraphic chart. Source: International Commission of stratigraphy⁵⁷

⁵⁷ International chronostratigraphic chart, <http://www.stratigraphy.org/ICChart/ChronostratChart2018-08.jpg> (accessed 16 August 2023)

Maps



Figure 7: Characteristic landforms of United States, source: NATGEO⁵⁸

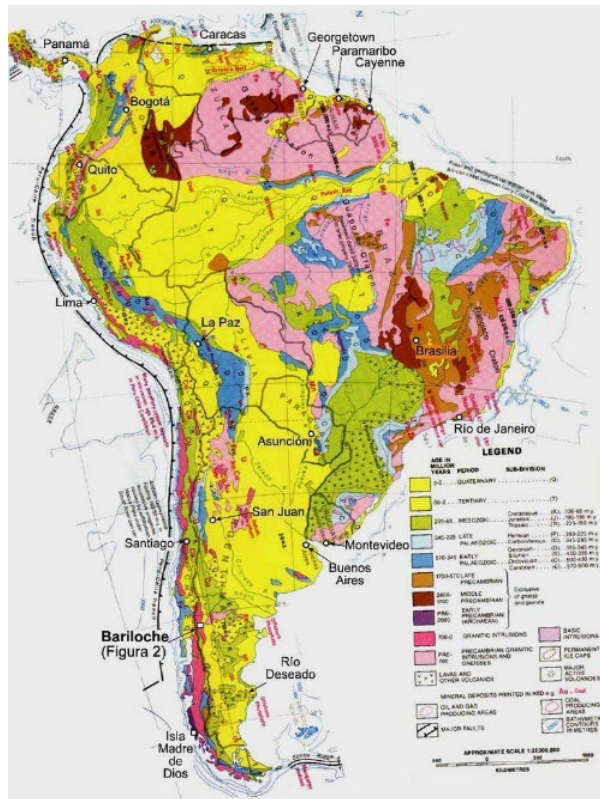


Figure 8: Geologic map and faults of South America. Source: GIFEX⁵⁹

⁵⁸ NATGEO. Mapping Landforms <https://www.nationalgeographic.org/activity/mapping-landforms/> (accessed 16 August 2023)

⁵⁹ GIFEX. Maps and satellite photos of the World. <https://www.gifex.com/> (accessed 16 August 2023)

Indicator dashboards

Dashboards are suitable presentation tools where more complex phenomena apply, for example coastal zone changes. The COINS (Coastal Indicator System) is an example using the 27 climate change indicators developed by the European Expert Group on ICZM and helps coastal planners take account of potential future impacts of climate change in their work. It is a web-based tool built on open source components and can be used free of charge.

Figure 9: COINS – Coastal Indicator System, source: European MSP Platform. COINS⁶⁰

⁶⁰ COINS, <https://www.msp-platform.eu/practices/coins-coastal-indicator-system> (accessed 16 August 2023)

6B. SEEA accounts/tables that use these statistics

Geographical and geological data and statistics are an important source of information about the physical characteristics of a country, and apply in various accounting themes, including agriculture, ecotourism and other economic activities. FDES introduces a selection of statistical components which facilitate consequent detailed accounting in relation to the economic activities included in SEEA.

The SEEA Central Framework focuses on individual environmental assets (land, water, etc.), while the SEEA Ecosystem Accounting applies to ecosystems (terrestrial, freshwater or marine). In particular, SEEA-EA defines and delimits ecosystems as spatial units using ecosystem extent accounts. Geological and topographic data are among the sources listed as potential inputs to defining the ecosystem types of a country, while wider administrative or physical delimitations are recommended for aggregation and reporting purposes.

6C. Commonly used indicators that incorporate these statistics

Statistics on natural disasters resulting from volcanic eruptions, earthquakes and landslides may include geological components. Statistics on sea-level rise, even though, commonly reported in climate-change packages, rely on data produced from geodetic measurement methods.

6D. SDG indicators that incorporate these statistics

All SDG indicators calculated as a proportion of a national territory (area of a country or region; costal area) require geographical and geological data and statistics.

Table 3. Examples of environmentally-related SDG indicators, required geographical and geological data and statistics

Indicator	Metadata
6.6.1 Change in the extent of water-related ecosystems over time	https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01a.pdf https://unstats.un.org/sdgs/metadata/files/Metadata-06-06-01b.pdf
14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density	https://unstats.un.org/sdgs/metadata/files/Metadata-14-0a-01.pdf https://unstats.un.org/sdgs/metadata/files/Metadata-14-0b-01.pdf
14.2.1 Number of countries using ecosystem-based approaches to managing marine areas	https://unstats.un.org/sdgs/metadata/files/Metadata-14-02-01.pdf
15.1.1 Forest area as a proportion of total land area	https://unstats.un.org/sdgs/metadata/files/Metadata-15-01-01.pdf

15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type	https://unstats.un.org/sdgs/metadata/files/Metadata-15-01-02.pdf
15.3.1 Proportion of land that is degraded over total land area	https://unstats.un.org/sdgs/metadata/files/Metadata-15-03-01.pdf
15.4.1 Coverage by protected areas of important sites for mountain biodiversity	https://unstats.un.org/sdgs/metadata/files/Metadata-15-04-01.pdf
15.4.2 Mountain Green Cover Index	https://unstats.un.org/sdgs/metadata/files/Metadata-15-04-02.pdf