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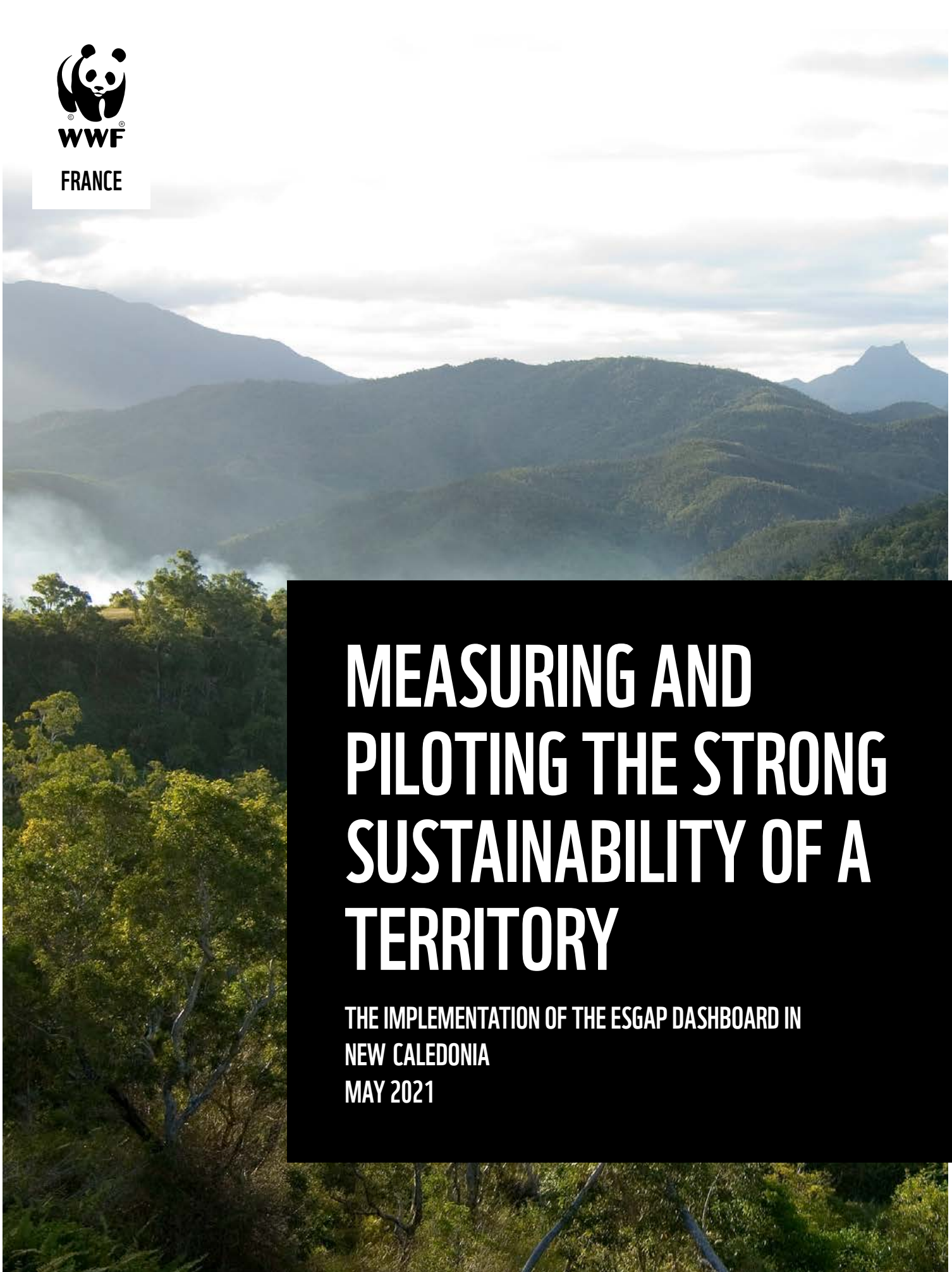

MEASURING AND PILOTING THE STRONG SUSTAINABILITY OF A TERRITORY

THE IMPLEMENTATION OF THE ESGAP DASHBOARD IN NEW CALEDONIA

MAY 2021

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Design
Muscade

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ACRONYMS

3DT: Direction du Développement Durable des Territoires (Department of Territorial Sustainable Development)

AFD: Agence Française de Développement (French Development Agency)

BII: Biodiversity Intactness Index

BRE: Bilan de Ressources en Eau (Water Resources Assessment)

CBD: Convention on Biological Diversity

CEN: Conservatoire d'Espaces Naturels (Conservatory of Natural Areas)

CIRED: Centre International de Recherche sur l'Environnement et le Développement (International Centre for Research on Environment and Development)

CNRT: Centre National de Recherche Technologique sur le Nickel et son Environnement (National Technology Research Centre on Nickel and its Environment)

DAM: Direction des Affaires Maritimes (Department of Maritime Affairs)

DAVAR: Direction des Affaires Vétérinaires, Alimentaires, et Rurales (Department for Veterinary, Food and Rural Affairs)

DASS: Direction des Affaires Sanitaires et Sociales (Directorate of Health and Social Affairs)

DCE: Débits Caractéristiques d'Étiage (Characteristic low flow)

ESGAP: Environmental Sustainability Gap

IBNC: Indice Biotique de Nouvelle-Calédonie (New Caledonia biotic index)

IBS: Indice Bio-Sédimentaire (Bio-sedimentary index)

ICPE: Installations classées pour la protection de l'environnement (Installations classified for protection of the environment)

IRD: Institut de Recherche pour le Développement (Research Institute for Development)

ISEE: Institut de la statistique et des études économiques (Institute of Statistics and Economic Studies)

GCRMN: Global Coral Reefs Monitoring Network

GHG: Greenhouse Gas

LU: Land use

SDG: Sustainable Development Goals

OFB: Office Français de la Biodiversité (French Office for Biodiversity)

WHO: World Health Organization

PEPNC: Politique de l'Eau Partagée de la Nouvelle-Calédonie (New Caledonia shared water policy)

SPREP: Secretariat of the Pacific Regional Environment Programme

MSY: Maximum Sustainable Yield

RORC: Réseau d'Observation des Récifs Coralliens (Coral Reef Monitoring Network)

ODS: Ozone Depleting Substances

SAP: Service de l'Aménagement et de la Planification (Department of Land Management and Planning)

SCRRE: Service de Coopération Régionale et des Relations Extérieures (regional cooperation and external relations service)

SES: Strong Environmental Sustainability

SESP: Strong Environmental Sustainability Progress

IOT: Input-Output Table

UNC: University of New Caledonia

WWF: World Wide Fund for Nature

EEZ: Exclusive Economic Zone

EXECUTIVE SUMMARY

The stakeholders responsible for implementing public policies for development and environmental protection need to monitor the state of the environment in order to evaluate the effectiveness of their actions, prioritize policies and management measures, and thus objectively establish their contribution to the conservation of biodiversity and natural capital.

- **The Environmental Sustainability GAP (ESGAP) is a synthetic indicator based on a dashboard that makes it possible to monitor the state of the environment from a strong sustainability perspective, i.e. by adopting stringent criteria on the non-substitutability of the natural capital by other forms of capital (including physical) in a territory or country.** It provides information on changes in the functional state of various components of the environment, focusing on the gaps that exist between these changes and the objectives of "good environmental state" associated with each of these components in order to maintain the proper functioning of the biosphere.
- Four themes (called "functions" within the ESGAP framework) are used to support the ESGAP: source (sustainable use of natural resources) (1), sink (critical pollution loads of ecosystems (2), life-support (biodiversity) (3), and human health and welfare (4).

Two composite indicators are used to measure the ESGAP:

- a composite indicator called Strong Environmental Sustainability (SES) that reflects the level of good environmental state to be maintained, or to be achieved, in relation to objectives defined by science, legislation or public policy;
- a composite indicator called Strong Environmental Sustainability Progress (SESP) that measures the gap between the current trajectory and a sustainable trajectory, with respect to the environmental objectives set out in the SES.

Supported by the AFD and WWF France, **this pilot project on implementation of the ESGAP dashboard in New Caledonia** aims to assess the operationality of this tool in territories where data on the state of the environment, and the pressures on it, are often fragmented. This evaluation was carried out by the Ecological Accounting Chair, hosted by CIRED and AgroParisTech. This study forms part of the set of experiments carried out on several sites, notably in Europe, mainly by a team from University College London[1].

WORKING METHOD

The field work in New Caledonia was carried out in several stages. Initial bibliographical desk work identified the scientific issues as well as important stakeholders to be consulted in this territory. Given the large number of dimensions covered by the ESGAP, local stakeholders were an essential source of information for successful completion of this project. Around thirty stakeholders responsible for environmental management (including decision makers, managers, research centres, associations, and the private sector) were consulted in order to discuss the environmental functions described and adapt them to the local context, define the environmental objectives to be achieved or maintained and the indicators associated with New Caledonian specificities, and collect the data necessary for the construction of the indicators. Lastly, statistical analyses were carried out to develop the SES and SESP composite indicators from the databases produced.

RESULTS ON THE FEASIBILITY OF SETTING UP THE ESGAP IN NEW CALEDONIA

Observation 1

As regards the possibility of completing, it is noted that it is not possible to obtain information for all of the ESGAP indicators for a territory such as New Caledonia within a reasonable timeframe and based on the available data. Thus (Figure 1, next page):

- 12 of the 22 ESGAP indicators could be constructed for the SES, including 4/5 for the source (sustainable use of resources) function, 2/9 for the sink (critical pollution load) function, 2/3 for the life-support (biodiversity) function, and 4/5 for the human health and welfare function. **At least one dataset per function could therefore be mobilized.**
- 7 of the 22 ESGAP indicators could be completed for the SESP, while five of the indicators completed for the SES did not have time series available.
- 1 indicator has been added to the SES and SESP: the area of trees and shrubs burned per year, integrated into the critical pollution load of ecosystems function.
- 2 of the 17 international databases identified by the University College London team have been mobilized here, the UNESCO State of Heritage Report and the global Biodiversity Intactness Index for the biodiversity indicator. Three other databases among those identified could have been mobilized but better quality local data were favoured (wood resources, soil erosion, drinking water).

[1] Ekins, P., B. Milligan and A. Usubiaga-Liaño (2019), "A single indicator of strong sustainability for development: Theoretical basis and practical implementation", AFD Research Papers, No. 2019-112, Revised draft, 21st December 2019.

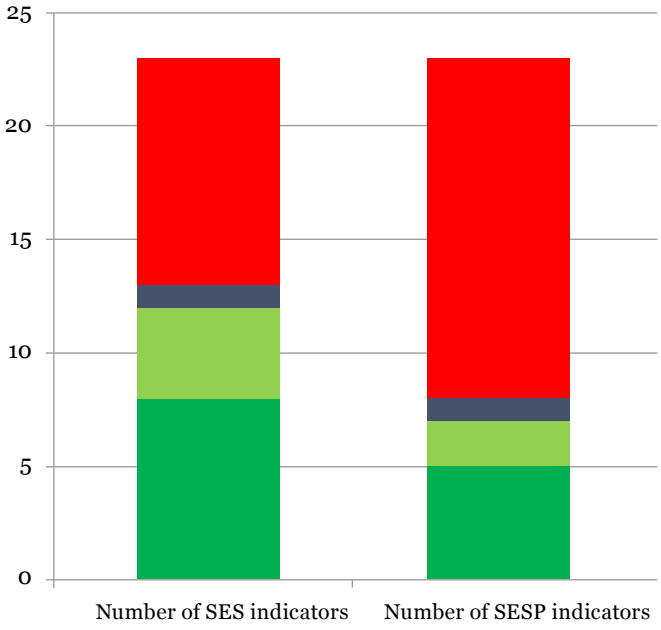

Figure 1. Status of ESGAP SES and SESP indicators in New Caledonia

Legend

Missing New Proxy Supported

Observation 2

Setting up the ESGAP requires a significant amount of work to define environmental objectives.

Indeed, while environmental objectives are mentioned in many legislative or political texts in Europe, this is not the case in a territory such as New Caledonia. Some standards already exist for functions relating to human health and welfare (e.g. bathing water quality or the status of UNESCO heritage sites), but this is not the case for resource use, pollution and biodiversity.

Moreover, some objectives must be adapted because their definitions in the European ESGAP project are not suitable for New Caledonia. This is the case for soil erosion that uses a threshold adapted to the European climate and geology but not to the Caledonian situation. However, comparison between countries may be hampered if objectives defined locally are used. For certain indicators, such as the sustainable use of fish resources or outdoor air quality, international standards based on scientific recommendations exist and have been used. In other cases, these standards under development in New Caledonia, such as the metal load of aquatic ecosystems, but other objectives are not yet available, such as the definition of an objective of good ecological state of freshwater ecosystems as it exists in Europe today. Finally, it appears that several objectives concerning the levels of terrestrial biodiversity and greenhouse gas emissions are still under debate at all scales of decision-making, and that a consensus objective is out of reach at the moment.

Observation 3

The creation of ESGAP indicators makes it possible to synthesize the state of the maintenance of the natural capital and may be used locally for environmental management. This gives a global vision on the maintenance of the natural capital in New Caledonia that was lacking given the fragmented monitoring and objectives, related to the large number of environmental stakeholders in New Caledonia distributed over various regions (three provinces in addition to the exclusive economic zone) and with various levels of governance (six levels between town halls, customary bodies, provinces, the government, the State, and international bodies such as UNESCO).

RECOMMENDATIONS FOR SETTING UP THE ESGAP IN OTHER TERRITORIES

Three lessons can be learned from applying the ESGAP tool in the case of New Caledonia as regards implementation of the ESGAP in other territories, in particular in the South.

- First, and in an obvious way, the use of bibliographic resources, interviews, and statistics (including spatial statistics) are necessary to cover the extremely wide range of environmental issues, in order to be able to construct indicators in the four dimensions of the ESGAP.
- Second, environmental objectives should be defined according to the intended use of the ESGAP, which can be used for cross-country comparisons or for implementing strategic environmental management in a specific territory. These choices may also be oriented depending on whether the objectives defined are scientifically supported and politically accepted.
- Three, the consultation phase is important for several reasons in order to ensure that the approach is relevant, collect quality data (that are not necessarily accessible in the public domain), and ensure appropriation by local stakeholders. This can be done by questioning their needs, their capacity to use such a tool, existing strategies and legislation, and environmental issues specific to national and local contexts.

RESULTS ON THE SUSTAINABILITY OF NEW CALEDONIA

The SES index score is 43%. This value is mainly driven by the low sustainability of the critical pollution load of ecosystems function (10%), linked to high greenhouse gas emissions and the impact of fire on ecosystems in New Caledonia. The other ESGAP functions can be qualified as relatively sustainable. The life-support function is the most sustainable (73%), followed by the source function (68%), then health and welfare (67%), and finally the sink function.

Two of the seven indicators retained for the SESP (Figure 2) have reached the stable objective over time. This is the case for fish resources. For a number of years now, tuna fishing in the Western and Central Pacific Ocean has been considered as sustainable by the Pacific Community. In addition, outdoor air quality has not exceeded the thresholds for fine particles (PM10, PM2.5) for several years. One indicator, the state of marine ecosystems, has not reached the good state objective and its evolution is on a positive trajectory but is not sufficient for reaching it by 2030. Another indicator, the state of the UNESCO heritage, has not reached the good state objective and is not progressing, being classified "Good with some concerns". Finally, three indicators (greenhouse gas emissions, burnt surfaces, bathing water quality) have trajectories that are moving away from the good state objective.

THERE ARE CLEAR LINKAGES BETWEEN THE ESGAP AND OTHER INTERNATIONAL, POLITICAL AND SCIENTIFIC FRAMEWORKS FOR REPORTING ENVIRONMENTAL INDICATORS

- ESGAP indicators can feed into or be fed by indicators on the state of the environment of the Sustainable Development Goals (SDG), in particular for Goals 6, 9, 11, 13, 14 and 15. Eight of the SDG monitoring indicators can be directly linked to the ESGAP indicators developed here, particularly for the source and sink functions. Five monitoring indicators can be indirectly linked, particularly to the biodiversity and health and welfare indicators. Only the good state of the marine biodiversity indicator does not correspond to any of the SDG monitoring indicators.
- The construction of the ESGAP is based on achieving scientific and public policy objectives that are becoming increasingly widespread on the international scale, notably with ongoing negotiations for the post-2020 global biodiversity framework of the Convention on Biological Diversity. Indeed, as opposed to the SDGs, there are many more state of ecosystem indicators.
- The ESGAP framework is a version that is more operational at all decision-making levels than the planetary boundaries framework. It is already available as dashboards and indicators that can be communicated to a variety of audiences. The development of the "Years to Sustainability" indicator on the current trajectory for maintenance of the natural capital would be clear and simple for understanding the sustainability issues and emergency levels, supplementary to the overshoot day related to calculation of the ecological footprint. The ESGAP framework will also make it possible to propose a monetary value for sustainability through the calculation of the cost for achieving sustainability (Monetary ESGAP). This approach is similar to the Unpaid Ecological Costs conceptualized in the national accounting arena. It was tested for on the theme of terrestrial ecosystems in New Caledonia, with an estimation of the destruction of habitats that amounts to 63.6 billion CFP francs.

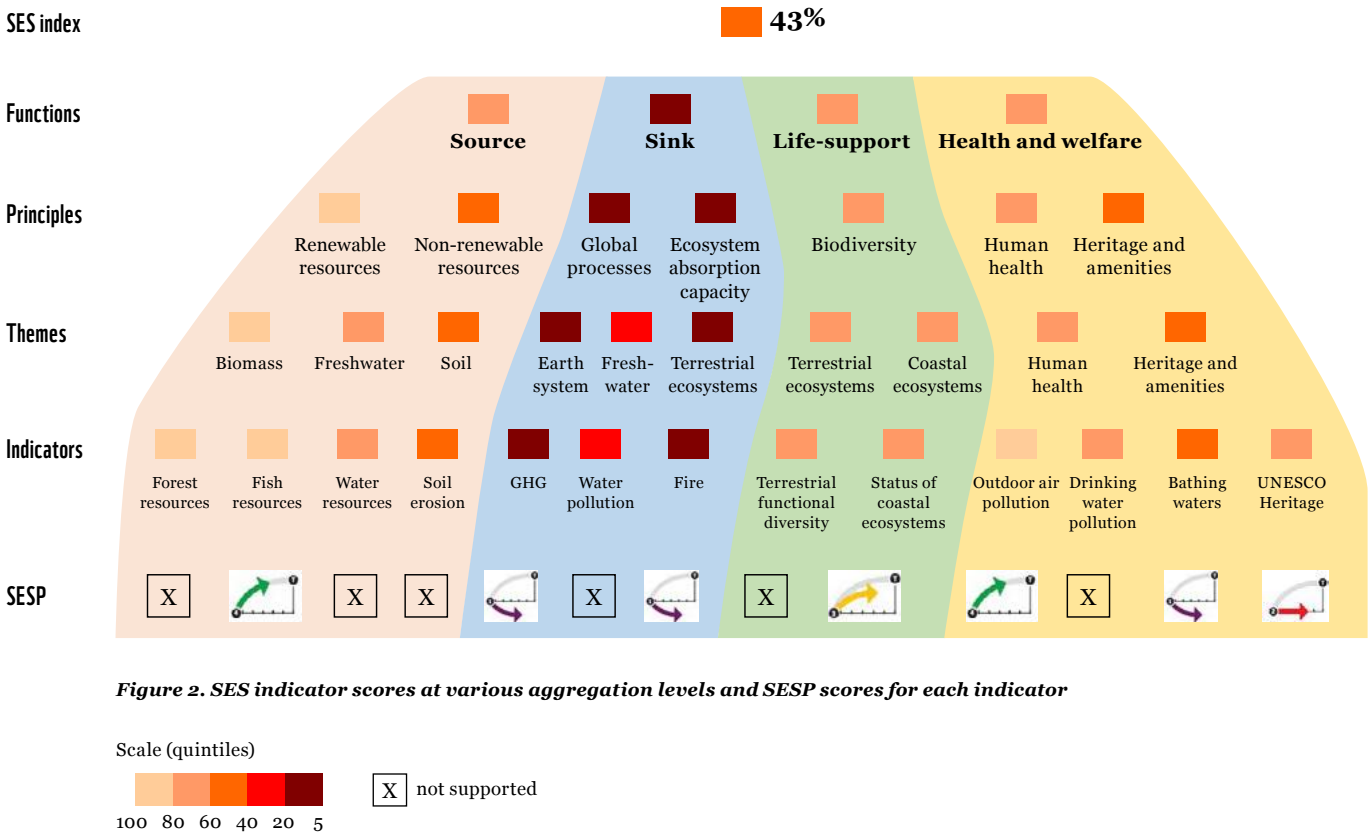

Figure 2. SES indicator scores at various aggregation levels and SESP scores for each indicator

Scale (quintiles)

100 80 60 40 20 5

X not supported

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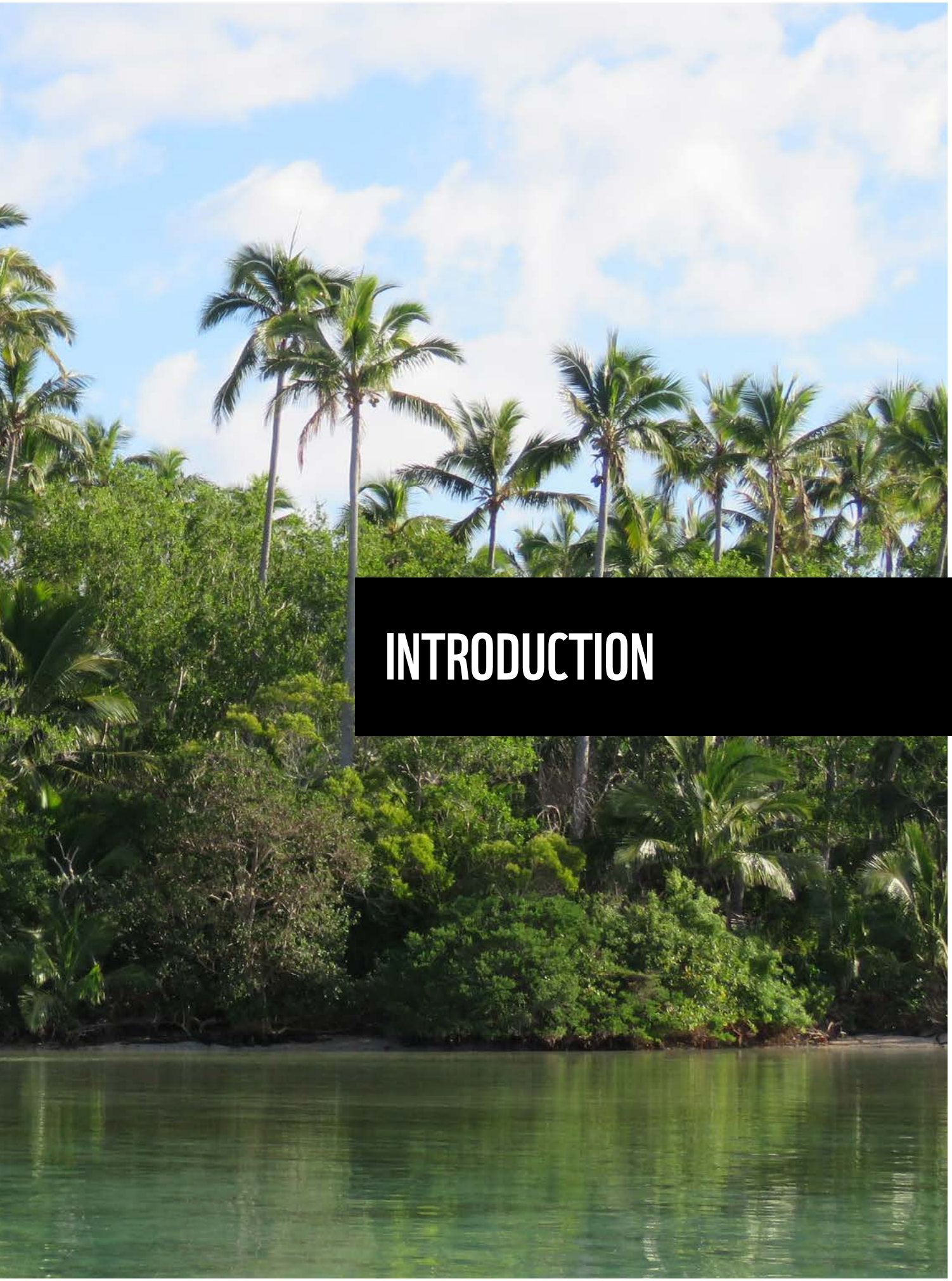

INTRODUCTION

ESGAP AND NEW CALEDONIA

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

This report consists of eight sections. The first section refers to the definition of the Environmental Sustainability Gap (ESGAP) and describes the environmental issues as well as the stakeholders related to environmental management in New Caledonia. Sections two and three describe the methodologies used. Section two focuses on the process for adapting the ESGAP to New Caledonia, whereas Section three focuses on the data and objectives used for the construction of the indicators, as well as the methodology for aggregating them into composite indicators. Section four presents the results of the study. Sections five, six and seven are discussions on the results regarding implementation of the ESGAP in New Caledonia. Section five discusses the implications for environmental management in New Caledonia. Section six discusses possible economic extensions on the use of the ESGAP indicators. Section seven discusses the revision of the global conceptual ESGAP framework. Lastly, references are found in Section 8.

This first section refers to the ESGAP definitions, its conceptual framework, as well as the dashboard and related indices. It then assesses New Caledonia's sustainability issues, and introduces the stakeholders responsible for public policies, monitoring, and protection of the environment in New Caledonia.

1 - THE ESGAP

The Environmental Sustainability GAP (ESGAP) is a dashboard for monitoring the state of the environment to aim for strong sustainability.

The most well-known definition of **sustainable development** comes from the Brundtland report (Brundtland et al., 1987), which defines it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Initially, economists interpreted this definition in a broad way, suggesting that sustainability is the maintenance over time of all capital, including not only the natural capital, but also the financial, human, social capital, etc. This definition of sustainability (known as weak sustainability) was operationalized by the genuine savings indicator, the implementation of which in New Caledonia is proposed in a report published by the AFD (French Development Agency) (Breland et al., 2009). **Another vision of sustainability postulates that a proportion of the natural capital, the critical natural capital, cannot substitute other forms of capital because the integrity of this natural capital must be maintained for ethical issues (ecocentrism, precautionary principle, etc.) and functional issues (resilience, dependence of societies, etc.)** (Ekins et al., 2003; Ekins, 2014). Practical aspects related to the definition of the scope of the critical natural capital and to the objectives of its maintenance defined by society have hindered the implementation of this sustainability approach, but are currently in the process of being resolved. This study contributes to its operationalization.

To establish a society that respects the strong sustainability criterion, public policies, development stakeholders, and environmental protection stakeholders therefore need to monitor the state of the environment in order to evaluate the effectiveness of their actions, prioritize policies and management measures, and thus contribute to conservation of the biodiversity and natural capital.

The Environmental Sustainability GAP (ESGAP) is a dashboard for monitoring the state of the environment to aim for strong sustainability (Ekins et al., 2019). This means that it focuses on maintenance over time of environmental functions necessary for the correct functioning of the biosphere (Ekins et al., 2003). Its development is based on the notion of critical natural capital to be preserved, which has led for example to the works on planetary boundaries (Steffen et al., 2015). Two quantitative composite indicators are used to measure the ESGAP: a composite indicator for measuring sustainability in relation to standards/benchmarks/objectives (SES - Strong Environmental Sustainability), and a composite indicator for measuring the progress towards achieving environmental objectives (SESP - Strong Environmental Sustainability Progress). Four environmental functions underpin the ESGAP: source (sustainable use of natural resources), sink (critical pollution load of ecosystems), life-support (biodiversity), and human health and welfare (Table 1).

FUNCTION	PRINCIPLE	THEME
SOURCE	Renew renewable resources	Biomass (forest and fishing)
		Water (surface water and groundwater)
	Use non-renewable resources cautiously	Soil
SINK	Global processes	GHG and ODS
	Respect the critical load of ecosystems	Terrestrial ecosystems (ozone, heavy metals, acidification, eutrophication)
		Freshwater ecosystems
		Coastal and marine ecosystems
LIFE SUPPORT	Maintain biodiversity	Terrestrial ecosystems
		Freshwater ecosystems
		Coastal and marine ecosystems
HEALTH AND WELFARE	Human health	Human health (indoor and outdoor air pollution, drinking water)
	Natural heritage and amenities	Heritage and amenities (Bathing waters, UNESCO World Heritage Sites)

Table 1. Descriptions of the ESGAP functions, principles and associated themes.

The aim of this project is to test the creation of ESGAP indicators for New Caledonia. The project is based on an initial study carried out on the European scale that led to the establishment of a methodology and dashboard with the SES and SESP indicators. The aim of the pilot project is to enhance and implement the ESGAP in New Caledonia, in order to inform public decision and drive advocacy for using this type of tool.

Some terms have been modified to clarify expressions and facilitate the understanding of the stakeholders met in the field:

Source -> resource
Sink -> pollution
Air pollution -> air quality
Amenities -> Heritage and amenities

2 - ENVIRONMENTAL ISSUES IN NEW CALEDONIA

New Caledonia is a specific territory in terms of environmental issues. It is a biodiversity hotspot enclosing significant endemism. A series of properties is included on the UNESCO natural world heritage list, and a wetland, la Plaine des Lac, is classified by the RAMSAR convention. It has a low human population (approximately 280,000 people), which is unevenly distributed over the territory. 75% of the population live in Province Sud (South Province) where the capital, Nouméa, is located. **The local economy has an impact on the environment, notably the mining and metallurgical sector industries.**

Terrestrial environmental issues are related to pressures due to fires, erosion phenomena, mining sites, forest fragmentation, erosive impacts of the ungulates introduced (Javan rusa, pig), as well as the particular geology of the ultramafic soils that make ecological restoration complicated. The same pressures apply to the freshwater ecosystems, with in addition a loss of freshwater biodiversity due to biological invasion (Black bass, Red-eared slider, Common water hyacinth, etc.). The marine environment focuses on specific issues, including management of the vast exclusive economic zone and its Natural Park of the Coral Sea, coastal and recreational fishing, tourism and cruise liners, coastal defences, and terrigenous sediments related to human activities on land. The atmosphere is also a significant issue, with greenhouse gas (GHG) emissions, the mining and metallurgical sector, heavy metals and asbestos.

3 - INSTITUTIONAL STAKEHOLDERS REGARDING ESGAP THEMES IN NEW CALEDONIA

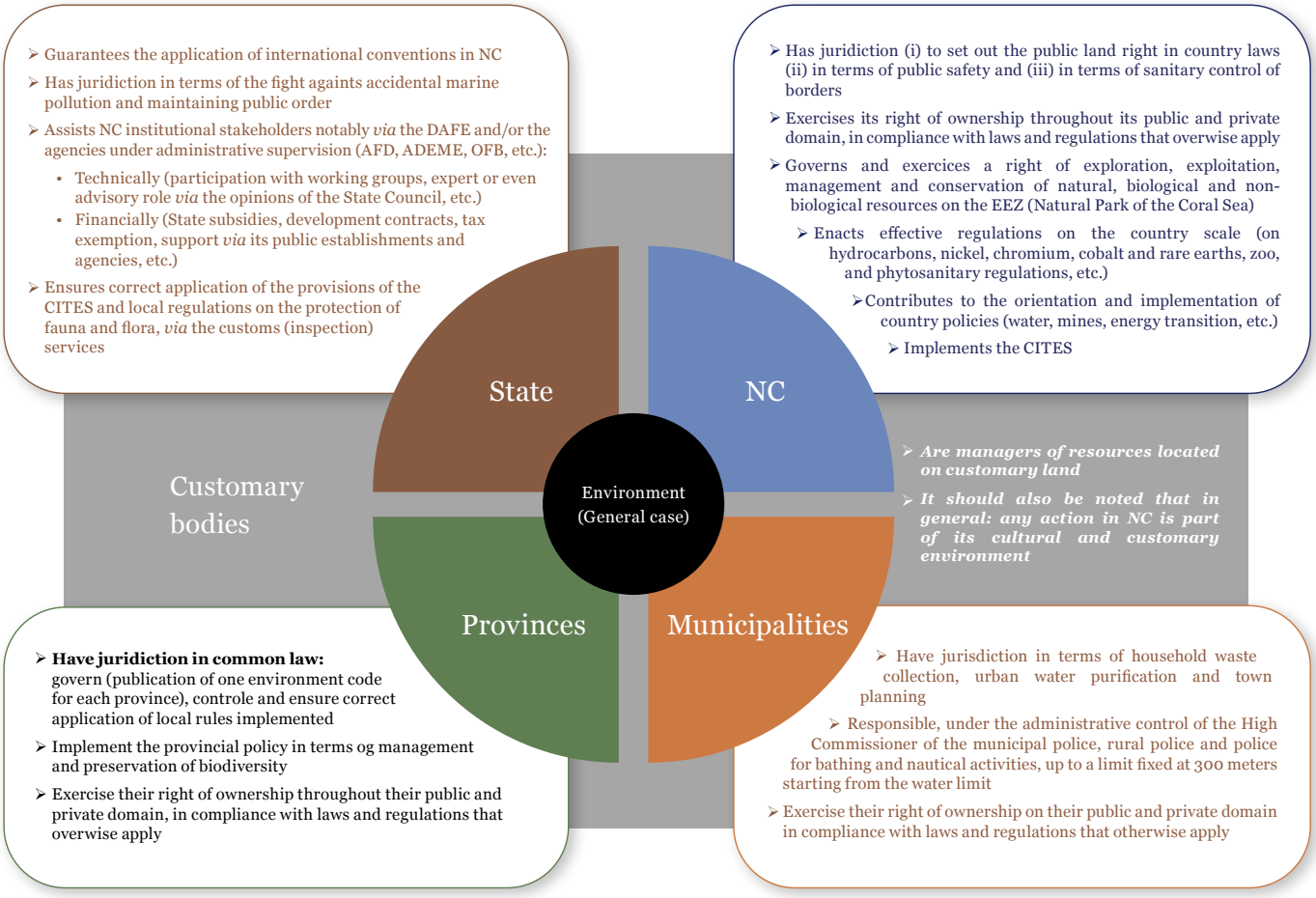

Figure 1. Distribution of environmental competences in New Caledonia. *Figure reproduced with the authorization of C. Fort, DAFE.*

There is a specific division of environmental management responsibilities in New Caledonia. These responsibilities are shared between the State, the Government, the Provinces, the Municipalities, as well as the Customary bodies (Figure 1). Moreover, a large number of non-governmental organizations have an influence on the environment or on the collection of environmental data, including local, international NGOs and associations, international organizations, the research sector as well as the private sector.

Many stakeholders are therefore producers, sponsors, or users of environmental data likely to be used as indicators for each of the four ESGAP functions (Table 2, next page).

In addition to the stakeholders listed in Table 2, we held discussions with other cross-functional stakeholders within the government: the *Service de l'Aménagement et de la Planification* (Department of Land Management and Planning), *Direction des Technologies et des Services de l'Information* (Department of

ESGAP FUNCTIONS	STAKEHOLDERS INTERVIEWED
SOURCE	SPC - Pacific Community DAM - Department of Maritime Affairs DAVAR - New Caledonia Department for Veterinary, Food and Rural Affairs Wood operators: Bois du Nord & SAEM Sud Forêt Œil - Environmental observatory Province Nord - Department of Economic Development and the Environment Province Sud - Department of Territorial Sustainable Development
SINK	CNRT Nickel and its environment DAFE - Department of Agriculture, Forestry and Environment DAVAR - New Caledonia Department for Veterinary, Food and Rural Affairs DIMENC - New Caledonia Industry, Mining and Energy Directorate Fonds Nickel IFREMER - French National Institue for Ocean Science IRD - Research Institute for Development Œil - Environmental observatory Province des îles Province Nord - Department of Economic Development and the Environment Province Sud - Department of Territorial Sustainable Development
LIFE SUPPORT	CEN - Conservatory of Natural Areas DAFE - Department of Agriculture, Forestry and Environment DAVAR - New Caledonia Department for Veterinary, Food and Rural Affairs Endemia - UICN Red List IFREMER - French National Institue for Ocean Science IRD - Research Institute for Development Œil - Environmental observatory Province Nord - Department of Economic Development and the Environment Province Sud - Department of Territorial Sustainable Development Pala Dalik
HEALTH AND WELFARE	Calédonienne des Eaux CEN - Conservatory of Natural Areas DAFE - Department of Agriculture, Forestry and Environment DAVAR - New Caledonia Department for Veterinary, Food and Rural Affairs Townhalls Province Nord - Department of Economic Development and the Environment Province Sud - Department of Territorial Sustainable Development SCAL AIR University of New Caledonia

Table 2. List of stakeholders who provided the data and qualitative information necessary for the construction of the ESGAP.

Technology and Information Services), and the *Service de la coopération régionale et des relations extérieures* (regional cooperation and external relations service). On the state scale, the OFB (French Office for Biodiversity) also provided its vision of the environmental challenges and competences, and on the regional scale, we exchanged views on information systems and data provided by the Secretariat of the Pacific Regional Environment Programme (SPREP). We also met with or obtained data from several NGOs (WWF, Pala Dalik), the AFD, the New Caledonia *Institut de la statistique et des études économiques* (ISEE - Institute of Statistics and Economic Studies), as well as a constellation of environmental design offices. **In total, around 30 stakeholders were identified across the territory.**

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ADAPTING THE FRAMEWORK

ADAPTING THE ESGAP FRAMEWORK TO NEW CALEDONIA

The ESGAP in its current form was developed conceptually based on the European Union as case study (Ekins et al., 2019). One of the objectives of this pilot project is therefore to evaluate whether the framework is suitable for implementation in other contexts, and notably in New Caledonia. This section describes the process for adapting the ESGAP to this territory, and the methodologies used to adapt the dashboard and indicators to the local context. Possible modifications of the functions, themes, environmental objectives associated with the ESGAP are explained.

1 - THE ESGAP ADAPTATION PROCESS

One of the objectives of this pilot project is therefore to evaluate whether the framework is suitable for implementation in other contexts.

Initial bibliographical desk work identified the scientific issues as well as important stakeholders to be consulted in New Caledonia. Given the large number of dimensions covered by the ESGAP, the environmental stakeholders in New Caledonia were a key source of information for successful completion of this pilot project. Subsequently, key stakeholders needed to be identified in order to understand the environmental issues, the institutions centralizing the environmental data, and those that drive the decision (which are not necessarily the same). Then, by "snow-ball effect", we identified the key stakeholders on each environmental indicator/theme. The mapping of stakeholders responsible for collecting or distri-buting environmental data took time. The help of WWF's local branch was important for an initial scan of the stakeholders having data in the various ESGAP dimensions.

Meetings were held with around 30 environmental stakeholders (including decision makers, research centres, associations, and the private sector) to discuss the importance of developing the ESGAP for New Caledonia, if necessary adapting the environmental functions described, the environmental objectives and the indicators associated with the Caledonian specificities, and obtaining the data necessary for the construction of the indicators.

A decision tree was used to analyse the suitability of the themes and objectives of the ESGAP in New Caledonia (Figure 2). This initial step was based on preliminary interviews with local stakeholders, notably WWF France's local branch, to identify important issues for New Caledonia and the ESGAP themes associated or not with these issues. The various ESGAP themes were retained or disregarded according to the issues present in New Caledonia, the availability of environmental objectives defining the standards, and the availability of data for developing each theme's indicators.

A significant amount of time was then dedicat-ed to establishing the database. First of all, a search of existing and publicly available data was carried out. The stakeholders identified were also requested to provide us with the data that they had. Information available in published reports was then extracted. Finally, for data that were not publicly available in database or report form, exchang-es and agreements for access to data were required.

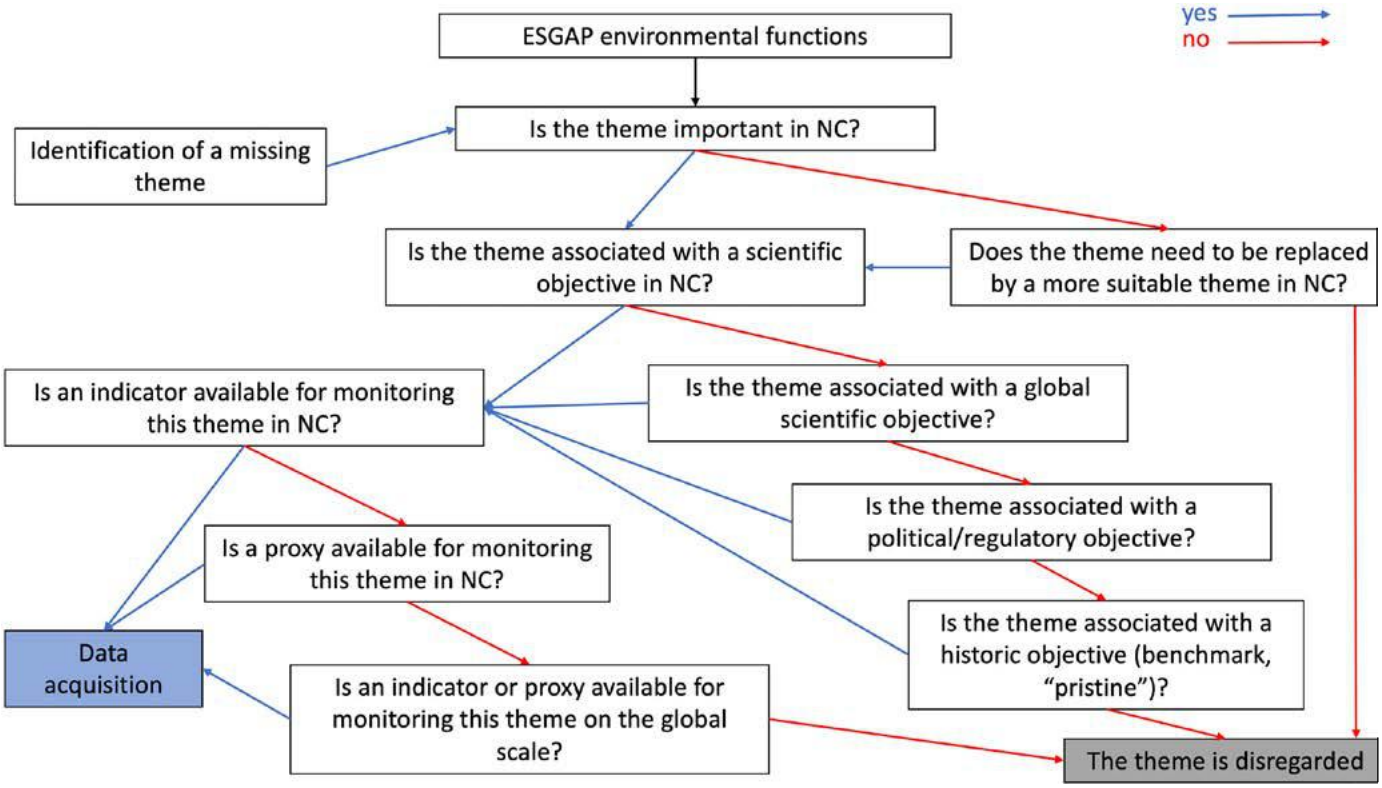

Figure 2. Decision tree for evaluating the relevance and feasibility of adapting each ESGAP theme to the territory.

In order to construct robust indicators, the available databases were qualitatively analysed under the lens of the RACER (Relevant, Accepted, Credible, Easy to monitor and Robust) tool, notably used by the European Commission and Eurostats. Lastly, statistical analyses and spatial statistics requiring the use of geographical information systems were finally produced in order to develop the SES and SESP indicators from the databases collected.

2 - ADAPTING AND ESTABLISHING ENVIRONMENTAL THEMES AND FUNCTIONS IN NEW CALEDONIA

The four ESGAP functions are source, sink, life-support, human health and welfare. The environmental issues identified in New Caledonia cover these four ESGAP functions. Therefore, these functions will not need to be modified to cover the question of sustainability in New Caledonia.

Nevertheless, several local issues are not present as indicators in the ESGAP developed for Europe:

- **Source:**

  The mining and metallurgical sector is one of the most impacting on the environment in New Caledonia and raises the question of the sustainable exploitation of natural resources. In the ESGAP and the work by Paul Ekins, non-renewable resources, such as mining activities, by definition cannot be sustainable and therefore are excluded from the ESGAP calculation. In this report, we follow this approach (other approaches may be considered such as the alternative discovery rate). Nevertheless, this sector of activity will indirectly affect other indicators (GHG, water quality, functionality of ecosystems).

- **Sink:**

  Fires constitute a major pressure on terrestrial ecosystems, notably forests (De Clerck et al., 2020). First, it affects the terrestrial ecosystems, but also constitutes a problem for water resources, and may cause catchment area problems that would then pollute the marine environment. In this report, we propose an indicator for monitoring these impacts.

- **Life-support:**

  The richness of coastal and marine ecosystems, including coral reefs, seagrasses, mangroves, sea mounts, and emblematic species (dugong) is different from that found in Europe, and raises the question of indicators for monitoring their sustainability. A significant terrestrial endemism also exists in New Caledonia, which is a biodiversity hotspot. Other indicators such as the Biodiversity Intactness Index (BII), like the UICN Red List, may complete the biodiversity indicators (see heritage) for the ESGAP in New Caledonia.

- **Health and welfare:**

  Possibilities other than taking the UNESCO sites are conceivable, given the political/arbitrary share in the designation of these sites. RAMSAR wetland sites are another possibility.

Some of the ESGAP's indicators do not apply to New Caledonia. The indicators related to groundwater (source + sink) cannot be supported, because most of the water resources used are surface water, and because the mapping of groundwater is not available. However, pollution issues are possible, and the situation of water resources is specific for the Province des Îles (Islands Province) that only has a freshwater lens. Indoor air pollution is another indicator that would be pointless applying here because this is mainly an issue that arises for countries where households are not very well equipped, which is not the case in New Caledonia.

Although there is an ecological continuity between Province Nord (North Province) and Province Sud (South Province - Grande Terre), the competences are different, as is the environmental monitoring. Therefore, some of these indicators are only available for one Province and not for another.

3 - ADAPTING AND ESTABLISHING ENVIRONMENTAL OBJECTIVES IN NEW CALEDONIA

The initial step of establishing the environmental objectives used as standards in the definition of sustainability was to analyse local scientific recommendations and standards.

The initial step of establishing the environmental objectives used as standards in the definition of sustainability was to analyse local scientific recommendations and standards. For this, environmental public policy documents were analysed, and the interviews held with the various stakeholders also enabled us to identify existing standards.

Very few regulatory or scientific objectives defined locally are available for the ESGAP functions (Table 3). Outdoor air quality standards are covered by a quantitative objective that should not be exceeded. The objectives are based on Metropolitan France regulations, regulations on *Installations classées pour la protection de l'environnement* (ICPE - installations classified for environmental protection) in Province Sud and international recommendations formulated by the World Health Organization (WHO) (Scal'Air, 2018).

Environmental objectives can be formulated for most of the indicators available for supporting the ESGAP in New Caledonia. These objectives are not formulated in local public policy documents. This is the case for the good state of the marine environment (coral reefs), soil erosion modelling, bathing water quality, fish biomass, water pollution, terrestrial ecosystem pollution, functionality of the terrestrial ecosystems and the state of conservation of UNESCO properties. Most of these objectives may be derived from the typologies used to create the indicators, i.e. the quantitative values are classified as being variations of "good", "only average", "insufficient", etc. For coral reefs, for example, the good state is defined with biological and ecological parameters by local scientists and experts, based on international work (Job, 2018). Another example, the good state of conservation of UNESCO properties is regularly assessed by UNESCO based on reports produced by the committees in charge of managing sites locally (CEN - Conservatory of Natural Areas - for New Caledonia) (Osipoval et al 2014, 2017).

In order to define objectives that do not have a pre-defined typology, such as GHG emissions, the benchmarks are from ESGAP Gold standard recommendations (Ekins et al., 2019) or author proposals. For the forest, there is no structured forest management policy in New Caledonia (Fort, 2020), and a proxy was used.

FUNCTION	INDICATOR	DESCRIPTION	TYPE	THRESHOLD VALUES	UNIT	SCALE	TIME	SOURCE	ESGAP LINKS
SOURCE	Forest resources	% of unexploited forest surface	Proxy	N/A	Surface per-centage	New Caledonia	N/A	ESGAP Global Datasets	Global Datasets
SOURCE	Fish resources	Assessment of the achievement of the maximum sustainable yield for five pelagic species	Scientific evaluation of stocks	Achievement of the MSY	Category	Regional	N/A	SPC	Gold Standard
SOURCE	Surface water resources	Positive flow rates available while protecting the reserved flow rate	Evaluation of watercourses	50% DCE 2	m^3/d	Province Sud	N/A	Province Sud, DAVAR	No
SOURCE	Soil erosion	Low sensitivity to erosion	Expert opinion, modelling	12	t/km^2/ year	Grande-Terre	N/A	UNC/Œil	Gold Standard, adapted threshold
SINK	Greenhouse gas	Compliance with the carbon budget available per inhabitant compatible with the Paris Agreement	Simplified rule, international treaty	2	tCO2/ capita	Global	2018-2100 period	ESGAP Gold Standard	Gold Standard
SINK	Fire pollution	No burned forest area caused by fires of human origin	Author proposal	0	Hectares	New Caledonia	N/A	Authors, Œil	No
SINK	Surface water pollution	IBS and IBNC indicators with good state	Index	IBS >= 5.45 and IBNC >= 5.3	No unit	Sites	N/A	Œil, Ethyco, 2015	No
LIFE-SUPPORT	Terrestrial functional diversity	"Biodiversity Intactness Index", average score of New Caledonia restructured with the thresholds	Expert opinion, modelling	Abundance >= 0.9 and Species Richness >= 0.8	Scale 0-1	Global	N/A	ESGAP Gold Standard; Steffen et al., 2015; Usubiaga et al., 2019	Gold Standard, adapted threshold
LIFE-SUPPORT	Ecological status of coastal ecosystems	Coral reefs in satisfactory state	Index, author proposal	“Satisfactory state”	Category	Sites	N/A	Pala Dalik	No
HEALTH AND WELFARE	Outdoor air pollution	Safe exposure to PM2.5 particles	France, ICPE, Province Sud and WHO regulations	10 and 25	$\mu g/m^3$	Nouméa	N/A	ESGAP Gold Standard, Scal'Air	Gold Standard
HEALTH AND WELFARE	Drinking water pollution	Treated drinking water distribution units	Proxy	100	%	New Caledonia	N/A	DASS/ DAVAR	No
HEALTH AND WELFARE	Bathing waters	Evaluation of water quality including the "Intestinal Enterococci" and "Escherichia Coli" parameters	Based on the standards ISO 7899-1/ ISO 7899-2 for the Enterococci and ISO 9308-3/ISO 9308-1 for E. Coli	"Excellent"	Category	Sites	N/A	DASS	Gold Standard, adapted threshold
HEALTH AND WELFARE	UNESCO Heritage	Evaluation of the state of conservation of UNESCO World Heritage Sites	Expert evaluation	"Good conservation outlook"	Category	Sites	N/A	Osipova et al. 2014	Gold Standard

Table 3. Environmental objectives retained for the New Caledonia ESGAP

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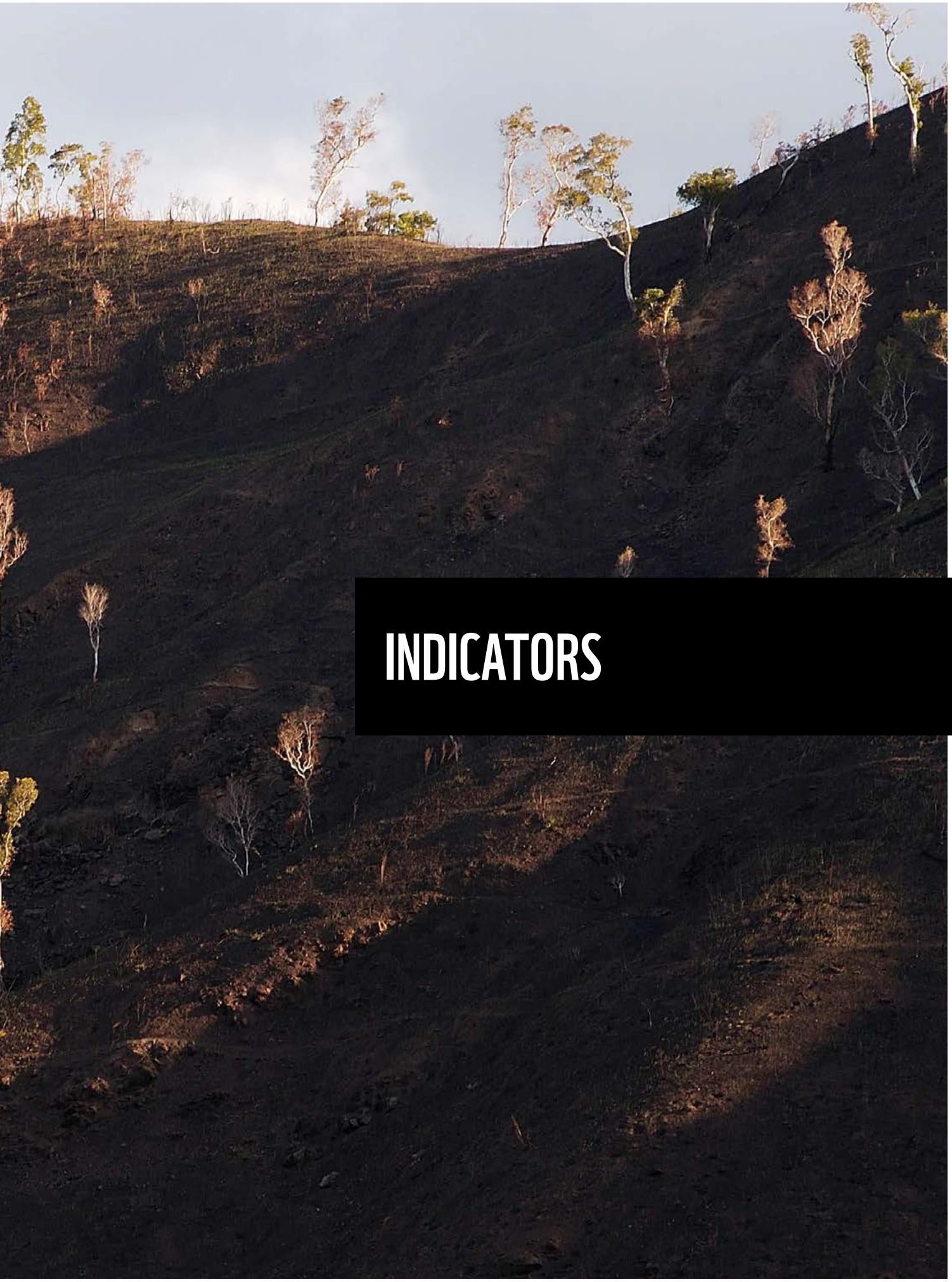

INDICATORS

CONSTRUCTION OF THE INDICATORS RETAINED FOR THE ESGAP IN NEW CALEDONIA

This section describes the objectives and the indicators that were retained for creating the ESGAP, then retranscribes the data and methodologies used to construct the database of the various indicators of the ESGAP, which was used to calculate the dashboard as well as the SES and SESP.

1 - SUMMARY OF THE OBJECTIVES AND INDICATORS RETAINED FOR CREATING THE ESGAP IN NEW CALEDONIA

The phase for adapting and constructing the environmental objectives and themes of the ESGAP in New Caledonia made it possible to identify two indicators for which the available information was sufficient, as well as 11 indicators for which it was possible to define objectives and collect suitable data for their construction (Table 4). Coherence between the availability of objectives exists, which involves monitoring and attention to public policies, and the availability of data for evaluating these objectives (diagonal in top left-hand corner to bottom right-hand corner in Table 4). Nevertheless, most of the indicators of the critical load for ecosystems theme form part of the possible objectives to be evaluated but for which data are not available in New Caledonia. Several indicators are also precisely monitored in New Caledonia (soil erosion, GHG, state of ecosystems, bathing waters), without political or scientific objectives being directly applicable. The three types

Legend

soil source function
ODS sink function
state life-support function
air health and welfare function

		INDICATOR		
		AVAILABLE	POSSIBLE	NOT POSSIBLE/INCOMPLETE
OBJECTIVE	AVAILABLE	Outdoor air UNESCO property		
	POSSIBLE	Soil erosion GHG Marine ecosysteme state Bathing waters	Surface water resources Forest biomass Fishing biomass Surface water pollution Terrestrial ecosystem pollution (fire) Terrestrial ecosystem state Drinking water	ODS Marine ecosystem pollution Terrestrial ecosystem pollution (ozone, heavy metals, acidification, eutrophication) Indoor air
	NOT POSSIBLE			Groundwater resources Water ecosystem state

Table 4. Summary of indicators and objectives retained in the New Caledonia ESGAP study.

of ecosystems have monitoring indicators, either in the sink function (freshwater), or in the life-support function (marine environment, or in both (terrestrial environment).

Compared to the indicators developed by the ESGAP study in Europe, 12 of the 22 ESGAP indicators could be met for the SES (Figure 3). At least one dataset per function could therefore be mobilized. One indicator was added to the SES and SESP, the area of trees and shrubs burned per year, in the critical pollution load of ecosystems function.

For the SESP, seven of the 22 ESGAP indicators could be met (Figure 3). For some indicators, data are only available for one year, or metho-dological breaks exists. This is the case for four of the indicators met for the SES: soil erosion, terrestrial biodiversity, surface water pollution and drinking water pollution. For the SES indicators, 4/5 were

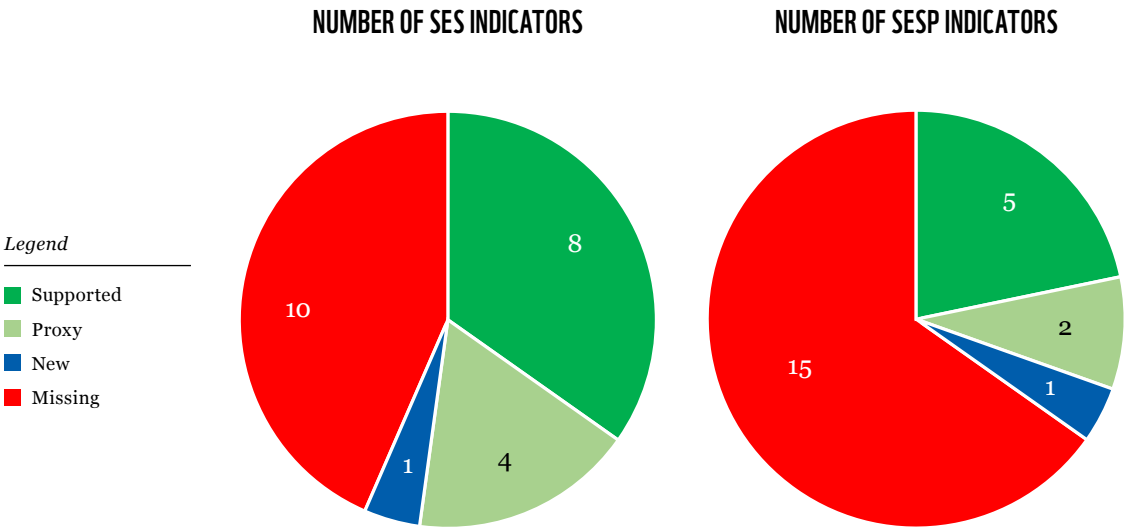

Figure 3. Status of the New Caledonia ESGAP SES indicators.

met for the source (sustainable use of resources) function, 2/9 for the sink (critical pollution load) function, 2/3 for the life-support (biodiversity) function, and 4/5 for the human health and welfare function. The source and health and welfare functions are supported based on indicators that are easily available for compiling the ESGAP (Figure 4). For the life-support (biodiversity) function, however, only 2/3 are available, one of which coming from local data and one coming from an international database. The sink (critical load) function has the greatest number of data availability problems for completing the indicators.

Implementing the ESGAP in New Caledonia made it possible to question three environmental issues: coral reefs, fire and mining activities. The state of health of coral reefs is a biodiversity issue in New Caledonia that is not present in Europe, and for which monitoring data exist both on the New Caledonia scale (RORC - Coral Reef Monitoring Network - monitoring) and on the global scale (Global Coral Reef Monitoring Network (GCRMN) - initiative). Therefore, it was used for the marine biodiversity indicator. Fire was integrated into the ESGAP as an additional indicator because it constitutes significant pressure on the environment in New Caledonia, associated with the critical load for ecosystems function. **Mining and metallurgical activities also apply significant pressure on the four ESGAP functions.** Their contribution is not taken into account directly, but they indirectly influence the scores of several indicators: GHG emissions, freshwater ecosystem pollution, and the functionality of terrestrial ecosystems.

Implementing the ESGAP in New Caledonia made it possible to question three environmental issues: coral reefs, fire and mining activities.

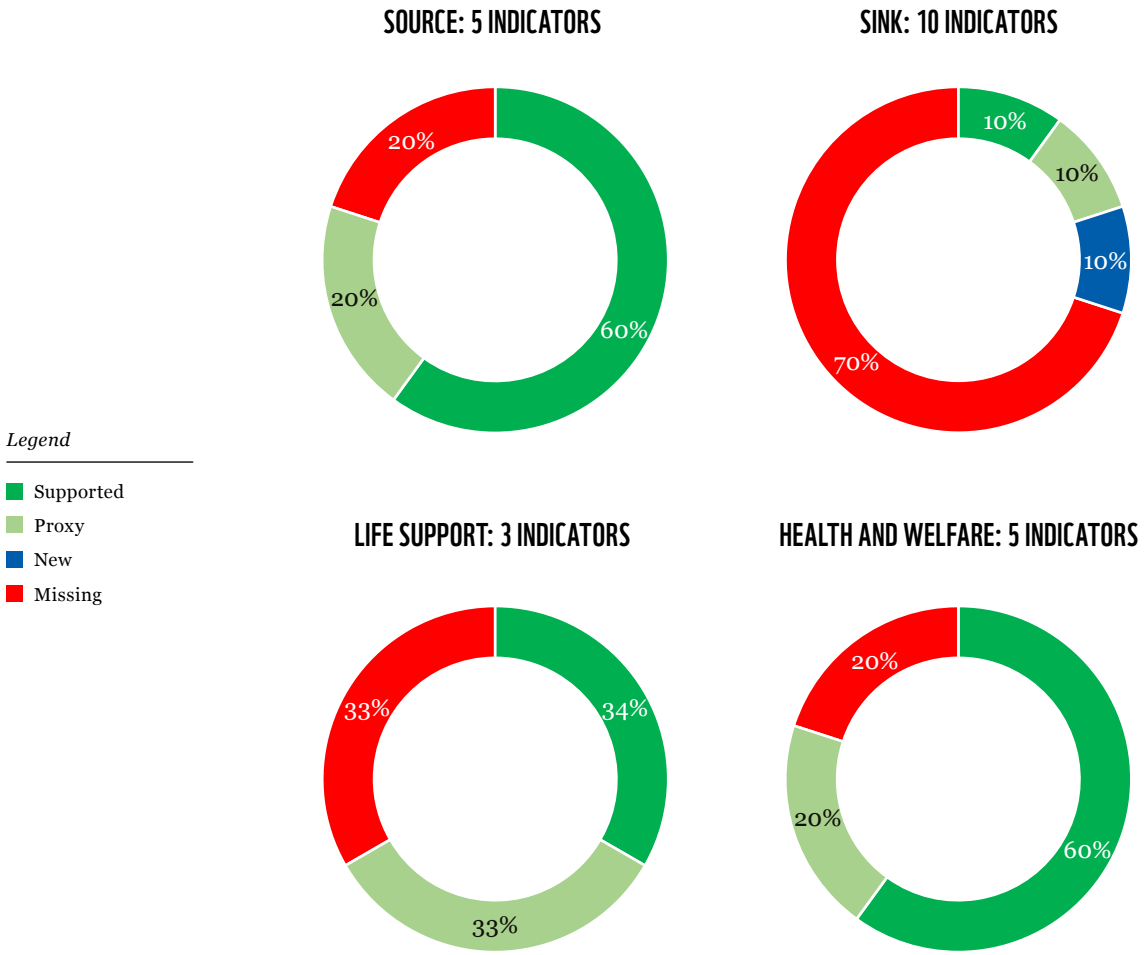

Figure 4. Status of the New Caledonia ESGAP SES indicators.

2 - DETAILED DESCRIPTION OF THE CONSTRUCTION OF INDICATORS

In this section, we describe in detail the data used for the construction of the ESGAP indicators in New Caledonia. An inventory of available data is produced for each indicator (Table 5), which describes the existence and the representativeness of the data, their accessibility, and two important factors for the construction of the ESGAP indicators, which are their spatialization and availability of time series. For this study, we only retained indicators for which the data were representative or partially representative of New Caledonia.

The data used for each indicator are then described in a summary way. Detailed information is provided for data that need special treatment in order to be usable. This is the case for information that is not standardized on an international scale, and for the proxies used, in order to construct the water resource, terrestrial ecosystem pollution, aquatic ecosystem pollution, and terrestrial biodiversity indicators.

Forest resources

Historically, forest exploitation was an important source of destruction of natural habitats and change of land use. Today, this activity is only practised on restricted land (a few thousand hectares) and mostly outside of natural forests (plantation *ex nihilo)*, mainly using non-endemic (Caribbean pine) or fast-growing native (sandalwood) species and slow-growing endemic species (kaori, coral reef araucaria). The most recent study aggregated on forest exploitation area data dates back to 2020 based on data from 2015, and was carried out for the Food and Agriculture Organization (FAO) (Fort, 2020). It follows on from a 2010 study (Oddi and Dang, 2010). Therefore, an approximative indicator of the variable that we are trying to describe (proxy) in terms of forest areas reserved for exploitation, rather than by biomass sampling, is used in this study.

INDICATOR	DATA EXIST	DATA ARE REPRESENTATIVE OF THE NC	DATA ARE PUBLICLY ASSESSIBLE	DATA ARE ACCESSIBLE ON REQUEST	DATA REQUIRING A SPECIFIC AUTHORIZATION	DATA COVER SEVERAL YEARS
FOREST RESOURCES	(X)	X	X			(X)
FISH RESOURCES	X	(X)	X	X		X
SURFACE WATER RESOURCES	X	(X)		X		
GROUNDWATER RESOURCES						
SOIL EROSION	X	X	X			
GHG	X	X	X			X
ODS						
OZONE POLLUTION	X		X	X		X
HEAVY METAL POLLUTION	X		X	X		X
ACIDIFICATION POLLUTION	X		X	X		X
EUTROPHICATION POLLUTION	X		X	X		X
FIRE POLLUTION	X	X	X	X		X
SURFACE WATER POLLUTION	X	(X)			X	X
GROUNDWATER POLLUTION						
COASTAL AND MARINE ECOSYSTEM POLLUTION						
TERRESTRIAL FUNCTIONAL DIVERSITY	X	(X)	X			
ECOLOGICAL STATUS OF FRESHWATER ECOSYSTEMS						
ECOLOGICAL STATUS OF COASTAL ECOSYSTEMS	X	X	X			X
INDOOR AIR POLLUTION						
OUTDOOR AIR POLLUTION	X	(X)	X			X
DRINKING WATER POLLUTION	(X)	X	X			
BATHING WATERS	X	X	X			X
UNESCO HERITAGE	X	X	X			X

Table 5. Qualitative analysis of the available data for the various ESGAP indicators.

X Criterion met (X) Criterion partially met

Fish resources

The data used for the fish resource biomass sustainable exploitation indicator come from the evaluation regularly carried out by the Pacific Community (SPC) on the evaluation of tuna fishing and stocks in the Western and Central Pacific Ocean (Brouwer et al., 2019). The indicator is constructed based on the achievement of a mortality compatible with the Maximum Sustainable Yield (MSY) for the four species assessed: South Pacific albacore (longfin tuna), bigeye tuna, bonito and yellowfin tuna.

Water resources

Currently, no directly usable indicator exists that would apply to the environmental objective in New Caledonia. One of the objectives of the Blueprint for a *Politique de l'Eau Partagée de la Nouvelle-Calédonie* (PEPNC - New Caledonia shared water policy) is to carry out an initial assessment of the water resource on the territory by 2023 (DAVAR, 2019). On Grande Terre, surface waters are mostly used. 90 per cent of drinking water comes from surface waters (DAVAR, 2019). Groundwaters represent a small share of the water used. The *Débits Caractéristiques d'Étiage* (DCE - Characteristic low flow) is available for 2008 and 2014 (Romieux and Wotling, 2016). The characteristic low flow represents the daily flow rate value below which the flow falls for 10 consecutive days in the year.

Province Sud ordered *bilans ressources en eau* (BRE - water resource assessments) for various catchment areas, in the sectors that were the subject of a specific study. These sectors were targeted with regard to land knowledge (low flow sensitive sectors, known exsiccation periods, increasing development of the agricultural demand mainly) (Gwennaelle Bourret, pers. comm.). These data, synthesized in a mapping layer, were used to produce the ESGAP's critical load indicator for aquatic environments (Province Sud, 2020). From the various scenarios of the BRE formulated, the scenario over a period of 5 years was used, using the following formula:

$$\text{Q available of a section} = \text{Flow}_{\substack{\text{gross}\\\text{section}}} - \text{Flow}_{\substack{\text{reserved to}\\\text{be maintained}}} - \begin{pmatrix}\text{Sum of all samples}\\\text{taken upstream of}\\\text{the outfall}\end{pmatrix}$$

with a reserved flow of 50% DCE for a period of 5 years. In the absence of sufficient data on the biological flow rates of New Caledonia's watercourses, Province Sud decided to retain this assumption. The future acquisition of knowledge about each watercourse may lead to clarification of these assumptions. Thus, Province Sud has effectively evaluated a mobilizable flow rate for each section. This work was carried out over a 10-year period (agricultural need being the top consumer) then reported over one month (30 days) for ease of use (Gwennaelle Bourret, pers. comm.). Other assumptions in the report use different periods (2 years, 10 years, 100 years - the longer the period, the higher the risk of water stress). Some scenarios also change the reserved flow, which is not necessarily adapted to all watercourses.

To date, only Province Sud has data. Province Nord has not started this type of study. On the îles Loyautés (Loyalty Islands), the freshwater lens is used, and no data was found regarding this matter. In the absence of other quantified data on the state of water resources, Province Sud's BRE are used here.

Soil erosion

Here, we used the RUSLE model that evaluates the erosion risk in New Caledonia by the University of New Caledonia (UNC) (Dumas, 2010). This is the same model used for the European version of the ESGAP. This model was developed for a single time period, 2001-2010. The erosion risk classification uses a 12T/ha/year benchmark, which is different from the 1T/ha/year threshold used in the European version of the Europe model.

Greenhouse gas

The energy observatory of the DIMENC (New Caledonian Industry, Mining, and Energy Directorate) compiles an inventory of direct emissions for New Caledonia, for each sector of activity, in tonnes of CO2 equivalent[2]. Data are available between 2005 and 2016. The ESGAP Gold Standard is used here.

Terrestrial ecosystem pollution (fire)

The main source of pollution currently in New Caledonia comes from fire. Historically, a number of fire uses existed, including the significant use of fire for the prospection and exploitation of mining deposits before the arrival of heavy mechanization. A new methodology using the European Sentinel satellite was implemented to map burned surfaces in 2018 and 2017 (De Clerck et al., 2020). Prior to 2018, other not so accurate satellite data were used. Given this methodology break, it is not possible to compare the 2018 data with data from previous years, with the exception of 2017. Moreover, no normative objective exists for establishing a standard. A "natural threshold" is proposed by Œil (New Caledonia environmental observatory) to separate the percentage of burned surface into three categories, which is just applied to the spatial statistic and which has no scientific or legal value. Here, we suggest using the forest and shrub habitat surface (such as defined in the 2014 Land Use) as terrestrial ecosystem critical load indicator. The impact of fires on the forest cover could affect land use and the fragmentation of habitats over the long term, which could also modify the BII index. Therefore, using this indicator runs the risk of double-counting.

[2] Available here: https://dimenc.gouv.nc/energie/lobservatoire-de-lenergie

Aquatic ecosystem pollution

The water resource observatory of the DAVAR (Department for Veterinary, Food and Rural Affairs) monitors the quality of freshwater ecosystems on the territorial scale, which is compiled in Oeil's Hydrobio database. Two watercourse pollution indicators are currently available: the *Indice Bio-Sédimentaire* (IBS - Biotic Sedimentary Index) for fine particle pollution and the *Indice Biotique de Nouvelle-Calédonie* (IBNC - New Caledonia Biotic Index). These data are available over several years, collected on a representative set of watercourses, and thresholds are produced (ETHYCO, 2016). An authorization request to use the data is necessary because although Œil has set up a database to store readings, it does not own them. The 13 owners of these data were therefore contacted, and most of them responded positively to our request. Not all of the data monitored and stored are of the same quality. Therefore, we limit the analysis to the IBS and IBNC containing more than 10 bio-indicator taxons and that are from readings taken during low flow periods, between September and December (N. Mary, pers. comm.). Two data series exist, as the methodology was updated in 2016. The samples taken after 2016 can still be used to calculate the indicators according to the former method. We will use the samples with the new method to calculate the SES. We obtained authorizations from most of the owners, corresponding to 292 samples since 2016. The representativeness of the data on the New Caledonia scale is highly debatable (even with all of the data in the database) because batches of bulky/important data come from regulatory monitoring in mining areas and this does not reflect the global context (A. Bertaud pers. comm.).

By only keeping the samples taken during the low flow period and containing at least 10 taxons, we get 180 usable samples. Using this method, data are available for 2016, 2017, 2018, and 2019, but few samples are available in 2018 (30) and 2019 (18). 2017 data (68 available samples) were therefore used. For the samples using the pre-2016 method, 575 out of 1,214 samples are kept on the same selection criteria.

Terrestrial biodiversity

The European ESGAP uses the Biodiversity Intactness Index (BII) indicator (Usubiaga et al. 2019). This indicator measures the degree of human impact on ecosystems (anthropization, etc.). The model uses two biodiversity aspects: species richness and abundance. Two recent studies model this indicator on the global scale in a spatially explicit way. The first study dates back to 2016 and the authors are in contact with the University College London (UCL) team in order to have several time points using this former version of the model (Newbold et al., 2016). The most recent study dates back to 2019 and improves the model but only models the BII for one year (Sanchez-Ortiz et al., 2019). Therefore, it cannot be used for the SESP, but it [this version] is used for the SES. Two scientific thresholds are then determined for these two parameters to characterize an ecosystem as "intact". These thresholds retained are 90% for abundance and 80% for species richness within the planetary boundaries framework, but an enormous discrepancy exists (some experts suggest a threshold of 30%) (Steffen et al., 2015). By applying the UCL calculation method to New Caledonia, the BII would be 0%, because no surface in New Caledonia exceeds an abundance of 90%. The calculation method was modified, taking the gap between the 90% (80%) threshold and the average value for abundance (species richness) as indicator for the whole of New Caledonia.

Marine biodiversity

The most comprehensive monitoring on the state of New Caledonia's coral reefs has been carried out for a number of years by Pala Dalik (other individual monitoring operations exist, including monitoring carried out in protected marine areas by the UNC). It gives an idea of the good state of health of the coral reefs, as well as a time evolution of each station evaluated using statistical analyses. Volunteers carry out the monitoring based on a RORC methodological guide. On the French scale, Ifrecor (French initiative for coral reefs) uses this database, as well as other individual data, to carry out a 5-yearly inventory of the coral reefs. The GCRMN also established its inventory of the Pacific in 2018 using this database.

Bathing waters

The DASS (Directorate of Health and Social Affairs) collects data on municipality bathing water quality. It uses various threshold values to define the bathing water quality (good, average, poor, requires closure). Two regulations are used to set the thresholds of the various categories: the New-Caledonian regulations in Deliberation 23/CP of 1 June 2010 and Decree no. 2010-3055/GNC of 1 September 2010 for the "good" and "requires closure" thresholds, and the regulations defined by ANSES (French Agency for Food, Environmental and Occupational Health and Safety) in Metropolitan France for the thresholds between the "average" to "poor" categories. Data are available in an aggregated way for all municipalities for 2015 and 2017. Four stations in Nouméa are present in 2015 and not in 2017. For comparison purposes, we therefore removed these 4 stations from the 2015 database (Plage 1000, Plage de Kaméré, Promenade Pierre Vernier Hobby Cats, Tindu).

Drinking water pollution

95 per cent of the New Caledonia population is supplied with running water (ISEE, 2016). A proxy was used to develop an indicator comparable to that of the European ESGAP. This is the percentage of drinking water distri-bution units that does not treat water before distribution. This indicator is a proxy that is totally satisfactory because the population may have treated water that anyhow exceeds the chemical or biological quality thresholds. If we use these data, determining an objective constitutes another obstacle. Targeting the whole population connected to a treated drinking water network (objective used here by default) seems fairly unrealistic.

Air pollution

Scal'Air has data on air pollution, notably PM2.5 and PM10 particles. Here, we follow the European ESGAP's methodology and only take PM2.5 particles into account, not PM10. The network operated by Scal'Air only concerns Province Sud. For the moment, data regarding other pollutants, responsible for pollution coming from road traffic and industry (SOX, NOX) are not taken into account.

UNESCO Heritage

The state of conservation of properties inscribed on the UNESCO world heritage list is subject to periodic evaluation (2014 and 2017 for the moment), and classifies the state of conservation of these properties according to evaluation reports produced locally (Osipova et al., 2014; 2017). The same method as that of the European ESGAP is used, by allocating a score of 1 to 4 according to the classification of the Properties. Here, the score is 3 out of 4 (75%) because the property is classified as "Good with some concerns".

3 - CALCULATING COMPOSITE INDICATORS

The SES is calculated as the difference between the actual value and the environmental objective, on a scale of 5 to 100, 5 being the worst score and 100 achievement of the objective.

The methods for aggregating the indicators of the ESGAP dashboard in order to calculate the two composite indices, the SES and SESP, are described below. They use the methods described in the UCL team's methodological report for the European ESGAP.

STRONG ENVIRONMENTAL SUSTAINABILITY

The SES is calculated as the difference between the actual value and the environ-mental objective, on a scale of 5 to 100, 5 being the worst score and 100 achievement of the objective. The normalization of elements between 5 and 100 was carried out using the following formula (1):

$$\text{value}_{new} = \frac{\max_{new} - \min_{new}}{\max_{old} - \min_{old}} \times (\text{value}_{old} - \max_{old}) + \max_{new}$$

In some cases, for example for GHGs that have a minimum value below the lower level recommended by the ESGAP (5%), as well as for the BII that must be re-normalized because the thresholds are between 90 and 80 for species richness and abundance respectively, we use the following normalization formula (2), where the minimum and maximum values (gp_{min} et gp_{max}) are the levels of the ESGAP indicator (5 and 100):

$$\text{norm} = \text{norm}_{min} + (gp_{max} - \text{norm}_{min}) \frac{\text{value} - gp_{min}}{gp_{max} - gp_{min}}$$

A geometric mean is used to aggregate the results at the various theme, principle, function levels, then at the final index level. As opposed to the arithmetic mean, the geometric mean is less sensitive to the highest values. The indicators are not weighted, as the weight is the same for each entity at each aggregation level.

Normally, the source data used for calculating the SES (and the SESP) are absolute values in the unit of measure suitable for the ESGAP dimension studied (e.g. CO2 equivalent emissions for the greenhouse gas aspect). However, in some cases, we only had access to "secondary" indicators, i.e. those already classified according to a good state scale, without the corresponding absolute value. This is the case for bathing water quality, soil erosion, the good state of the marine environment, the state of conservation of UNESCO properties, and aquatic ecosystem pollution.

This use of indicators instead of absolute data does not cause any problems in defining the SES, since a value between 0 to 100 can be defined using these data. On the other hand, it is not possible to estimate a value for the severity of the SES using these data.

STRONG ENVIRONMENTAL SUSTAINABILITY PROGRESS

The SESP is calculated based on the actual trajectory of the dimension studied in relation to the linear trajectory for achieving the environmental objective. Where possible, it is calculated over a period of 5 years. The following formulas are used to calculate the SESP. Formula (3) is used to calculate the actual trajectory of each indicator, and Formula (4) is used to calculate the trajectory that would allow the objective to be achieved at a given year. This year for achieving the objective has been arbitrarily set at 2030, but also refers to the temporality for achieving the SDGs and is the value used in the European version of the ESGAP. Formula (5) is used to calculate the ratio between the actual trajectory and the trajectory for achieving the objective in 2030 for each indicator.

$$(3) \qquad CAGR_a = \left(\frac{y_{t_1}}{y_{t_0}} \right)^{\frac{1}{t_1 - t_0}} - 1$$

$$(4) \qquad CAGR_r = \left(\frac{x_{t_r}}{y_{t_0}} \right)^{\frac{1}{t_r - t_0}} - 1$$

$$(5) \qquad R_{a/c} = \frac{CAGR_a}{CAGR_r}$$

NOTE ON SEVERITY

The first two indicators do not give any indication on the severity of the exceedance of the environmental objective. For example, for the bathing water quality, only the percentage of stations with excellent quality is taken into account as the SES and SESP value is therefore the same regardless of the value for the other stations (“good quality”, “insufficient quality”, “poor quality”, etc.). Future development of the ESGAP would establish a severity index for each indicator, in order to obtain more in-depth information on the state of sustainability.

Future development of the ESGAP would establish a severity index for each indicator, in order to obtain more in-depth information on the state of sustainability.


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RESULTS

THE ESGAP DASHBOARD IN NEW CALEDONIA

43%

THE SES INDEX SCORE

This value is mainly due to the low sustainability of the sink (critical pollution load of ecosystems) function.

This section describes in detail the results of the dashboard and SES and SESP indices for New Caledonia. It then assesses the links between the ESGAP indicators developed and two other international environmental monitoring initiatives, the Sustainable Development Goals (SDG) and the monitoring of the objectives of the post-2020 global biodiversity framework.

1 - THE ESGAP DASHBOARD IN NEW CALEDONIA

The SES index score is 43% (Figure 5). This value is **mainly due to the low sustainability of the sink (critical pollution load of ecosystems) function (10%)**, related to high GHG emissions and the impact of fire on ecosystems in New Caledonia. The other ESGAP functions are relatively sustainable. **The life-support (biodiversity) function is the most sustainable (73%)**, followed by the source (resources) function (68%), then health and welfare (67%), and finally the sink (critical pollution load) function.

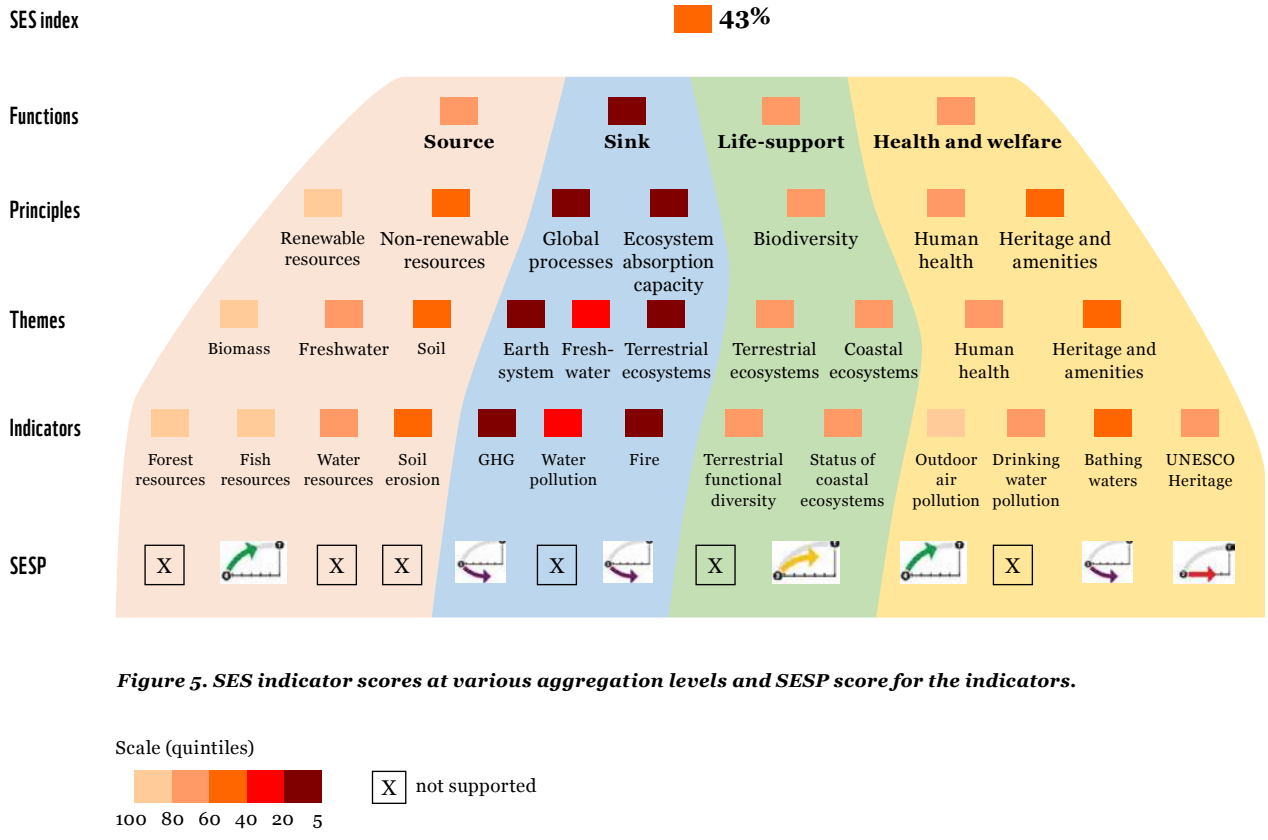

Figure 5. SES indicator scores at various aggregation levels and SESP score for the indicators.

The progress towards sustainability is negative for three indicators: GHG, fire and bathing waters, i.e. these indicators are moving away from their objective. The sustainability value is stable for the UNESCO heritage. The progress towards sustainability is positive but lower than the trajectory necessary for achieving the objective of good state of coastal ecosystems. Lastly, **outdoor air pollution and fish resources follow a trajectory in line with their sustainability objectives.**

The lowest SES sustainability values are associated with the sink (critical load for ecosystems) function. This is also the function with the lowest number of ESGAP indicators that could be constructed. This function pulls the SES index downwards.

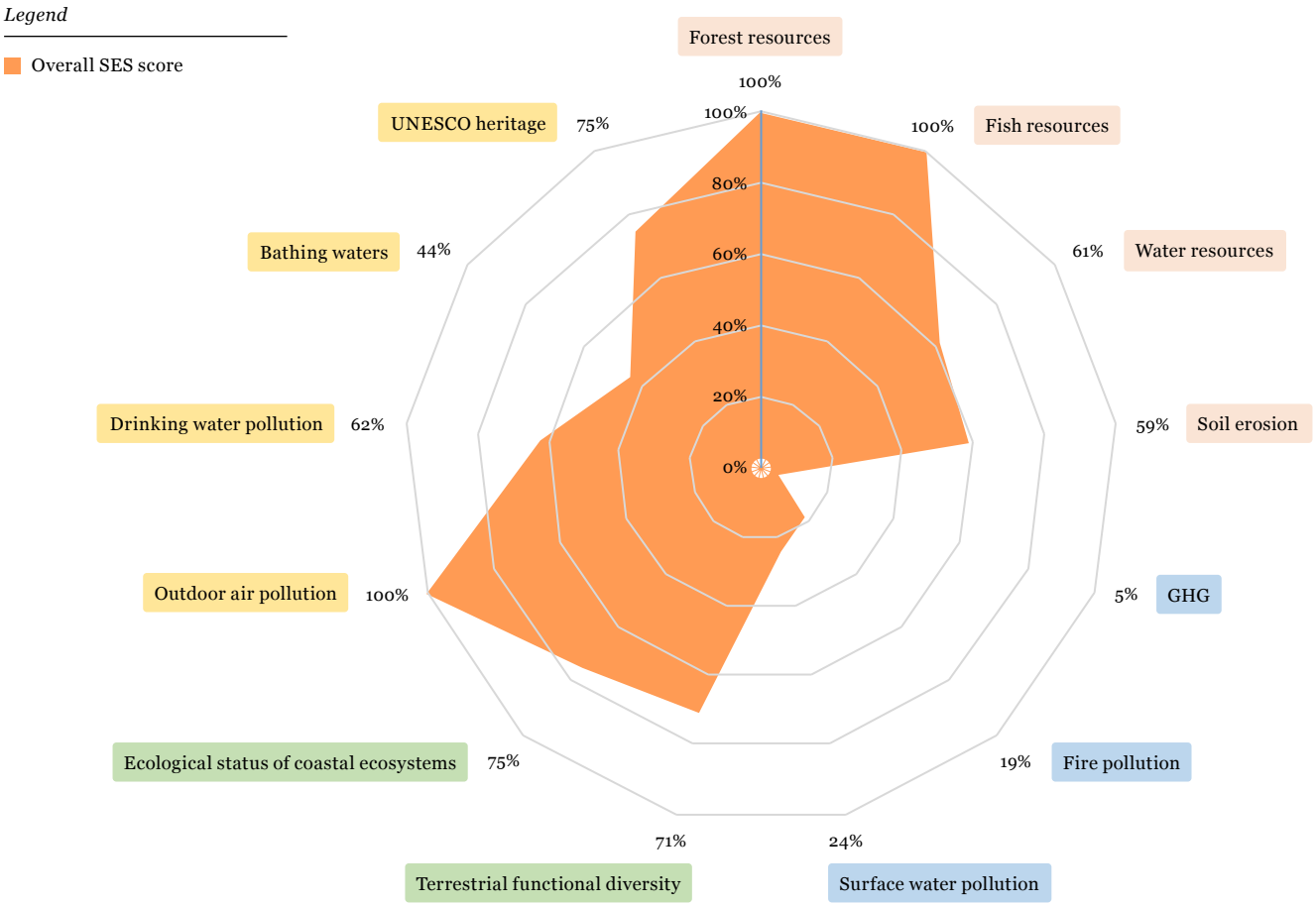

Figure 6. Values (in percentage of achievement of the objective) for the indicators retained in the SES in New Caledonia.

2 - LINKS BETWEEN THE ESGAP AND TWO MAJOR INTERNATIONAL SUSTAINABILITY MONITORING FRAMEWORKS

The various ESGAP indicators could be used for the reporting of Sustainable Development Goals (SDG). A proportion of the SDGs effectively refer to sustainability, although most of the SDG monitoring indicators are indi-cators for monitoring the means (resources, public policy documents, proportions of protected areas), rather than monitoring the state of the environment.

The ESGAP's SES indicators effectively address the themes present in several of the 17 SDGs, including Goal 6, 9, 11, 13,

The various ESGAP indicators could be used for the reporting of Sustainable Development Goals.

14, and 15[3] (Figure 7). The ESGAP indicators implemented in New Caledonia can be directly linked to 8 SDG monitoring indicators. Therefore, the ESGAP data may be used for the reporting of SDGs.

The other ESGAP indicators are also indirectly related to 8 SDG monitoring indicators. For example, the ESGAP uses the state of conservation of UNESCO properties as an indicator of the health and welfare function, whereas the indicator retained for monitoring the SDGs is the total expenditure per inhabitant dedicated to the preservation, protection and conservation of the entire cultural and natural heritage (11.4.1).

Only one ESGAP indicator, the good state of the marine environment, does not directly correspond to one of the indicators for monitoring the SDGs, even for SDG14 regarding the ocean. A more comprehensive version of the ESGAP with the missing indicators could also help to monitor the SDGs, notably 14.1.1 on coastal eutrophication. Most of the ESGAP indicators correspond to a different SDG indicator, but not in the case of water (SDG 6.3.1 & 6.3.2) for which several ESGAP indicators correspond.

On the other hand, the SDG monitoring indicators are not associated with the environmental objectives, and therefore are not sufficient to be used within the framework of the ESGAP.

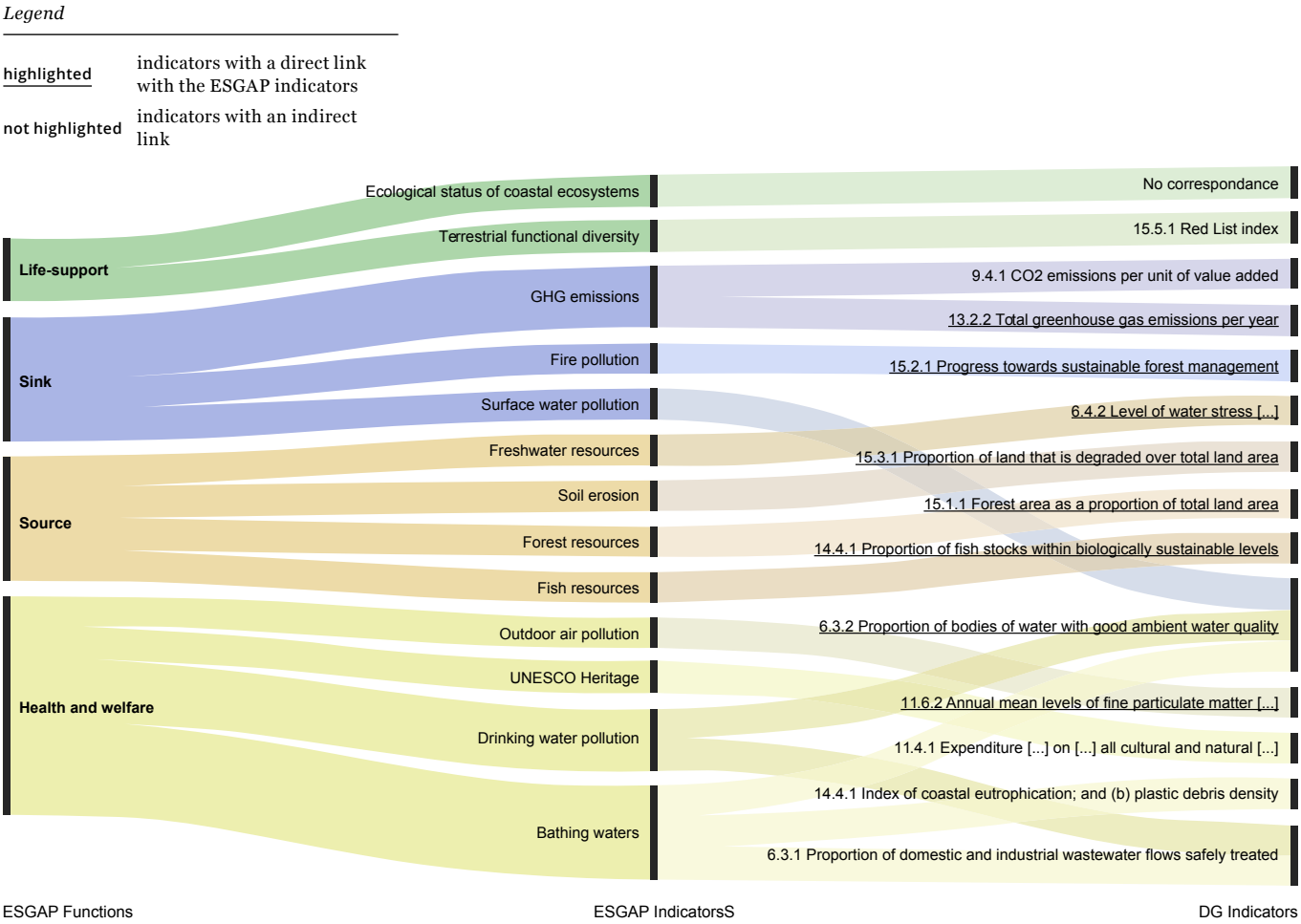

Figure 7. Correspondences between the ESGAP functions, ESGAP indicators developed for New Caledonia, and the Sustainable Development Goal monitoring indicators.

[3] "Goal 6. Ensure availability and sustainable management of water and sanitation for all", "Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation", "Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable", "Goal 13. Take urgent action to combat climate change and its impacts", "Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development", "Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss".

ESGAP AND MONITORING INDICATORS OF DRAFT 0 OF THE POST-2020 FRAMEWORK AGREEMENT OF THE CONVENTION ON BIOLOGICAL DIVERSITY

The preliminary version of the framework for monitoring the objectives of the post-2020 global biodiversity framework identifies a certain number of possible indicators in order to measure and monitor the progress for achieving the objectives that will be negotiated during the COP15 of the Convention on Biological Diversity (CBD) (SBSTTA 2020). The preparatory documents produced by the SBSTTA (Subsidiary Body on Scientific, Technical and Technological Advice) of the CBD provide a basis for comparing the compatibility between the indicators developed by the ESGAP and the indicators for monitoring biodiversity. The current version of the CBD agreement contains four objectives[4] for which 67 indicators have been pre-identified. It also contains 20 targets, for which 161 indicators have been pre-identified.

These documents also refer to other international environmental policies such as the SDGs. The aim of these indicators is to monitor the evolution over time of the biodiversity, with a 2050 deadline and an intermediate 2030 deadline. Therefore, the ESGAP seems interesting because a time dimension is present with either the "Years to Sustainability" or the SESP.

Generally, many indicators on the state of ecosystems and the pressures that affect them are listed as potential indicators. This variety makes the whole much more comprehensive than the ESGAP, but also raises a number of questions. Notably, the robustness of all of the indicators proposed is not explained, as the Ocean Health Index is present for example. However, this index was left out of the ESGAP because its calculation was not based on satisfactory quality data. The Red List and Ecological Footprint indicators are also present despite their methodological bias. As for the SDGs, some indicators concern the state of ecosystems, pressures, or implementation means. As opposed to the SDGs, there are many more state of ecosystem indicators.

Goal A concerns the scope, connectivity and integrity of ecosystems. Many indicators are listed, but only one is included in the ESGAP. The first ESGAP indicator is concerned, the proportion of forest cover and its evolution over time is one monitoring indicator identified. Another interesting forest monitoring indicator for the ESGAP is the evolution of the fragmentation of forests. For the moment, no data source has been identified by the SBSTTA of the CBD, therefore it would be relevant to develop this theme in the ESGAP. The second ESGAP indicator present in the panel of monitoring indicators for Goal A is the Biodiversity Intactness Index. On the other hand, they refer to WCS as guardian of the database, which is not the one that we use. The third indicator is the state of health of coral reefs. We use local data to meet this indicator, but the GCRMN has a global database with the same types of data. The new indicator proposed in the ESGAP version in New Caledonia, the impact of fires on forest ecosystems, is not directly present in the list of indicators for Goal A, but it is similar to the loss of forest surface indicator developed by the World Resources Institute (Global Forest Watch).

Goal B concerns nature's contributions to societies. Here, we find the ESGAP indicators related to the good quality of water bodies. The maintenance of properties classified on the UNESCO world heritage list is not identified in Goal B but could be one of the indicators for monitoring nature's contributions to cultural values (B.3).

Goal C regarding genetic resources and Goal D regarding the implementation means do not correspond to any ESGAP indicator.

In addition to the synergies related to the development of reporting for several international conventions, development of the ESGAP may also keep the conversation going on the need for and selection of headline indicators (SBSTTA 2020). **The ESGAP indicators, related to a clear conceptual framework, the critical natural capital, form an interesting list for prioritizing the efforts to be made by the international community for establishing environmental monitoring.** It could be interesting to move closer to the *Biodiversity Indicators Partnership*, an international initiative on the promotion of biodiversity indictors, which works on the establishment of monitoring operations for the post-2020 global biodiversity framework[5].

[4] Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society. Goal B: Reduce the direct pressures on biodiversity and promote sustainable use. Goal C: Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity. Goal D: Enhance the benefits to all from biodiversity and ecosystem services. Goal E: Enhance implementation through participatory planning, knowledge management and capacity-building (SBSTTA 2020)

[5] https://www.bipindicators.net/

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RECOMMENDATIONS

USING THE ESGAP TO MANAGE THE ENVIRONMENT IN NEW CALEDONIA

Construction of the ESGAP dashboard and indicators may constitute an environmental management tool in New Caledonia. In this section we will address three aspects that are essential for its local use. The results obtained for New Caledonia will be discussed first, focusing on the use of alternative data and the methodological difficulties related to time series. Then, we will discuss the use of the ESGAP indicators for monitoring public policies in New Caledonia. Lastly, recommendations on data acquisition and continued monitoring will be proposed.

1 - DISCUSSION ON THE RESULTS OBTAINED FOR NEW CALEDONIA

ESGAP indicators are constructed based on the methodologies used for the ESGAP Gold standard project in Europe, adapting them to the context and available data in New Caledonia. In this section, the use of alternative data and the methodological issues for constructing indicators related to the available data will be discussed.

It should be noted that the results of the studies on setting up the ESGAP in other countries are not yet available. Therefore, it will not be possible to compare the results obtained in this report.

Alternative data and areas for improvement for each indicator

Forest resources

The available data concern the surfaces exploited and the biomass extracted, and they concern almost the entire extraction outside of natural forests (only plantations). The biomass increase is highly heterogeneous over the territory, which makes defining a biomass increase threshold for calculating sustainable wood resource extraction problematic. This is particularly so as the increase in biomass on volcano-sedimentary soils may be produced predominantly by invasive species that are only partly valuable in terms of wood (*pinus, Cedrella odorata, Leucaena leucocephala, Tecoma stans,* etc). Therefore, a proxy in terms of forest areas reserved for exploitation, rather than by biomass sampling, is used in this study. Since 2012, two forest exploitation management bodies have been set up: SAEM Sud Forêt for Province Sud, and Bois du Nord for Province Nord, which may structure the available data to report on the sustainable aspects of the sector.

Fish resources

Coastal fishing may cause an overexploitation of certain fish resources in lagoon waters (e.g. the collection of mangrove tree crabs with a large number of pots in the mangroves). Data from fishing logs collected by Province Nord and Province Sud were provided, and include catches by species and by years. In the absence of data on the state of stocks, we cannot use these data in this report that aims to use comparable data between countries, based on achievement of the maximum sustainable yield.

Water resources

Currently, no directly usable indicator exists that would apply to the environmental objective in New Caledonia. WWF produced a diagnosis of the forest cover water supply service for the catchment protection perimeters. However, it is not backed up by a regulatory or scientific objective and its framework is not representative of all water resources in New Caledonia (Do Khac et al., 2019; Andreoli et al., 2016). Therefore, it will not be used here.

To improve the robustness and representativeness of the indicator, work may be carried out in the other Provinces on the establishment of assessments and on definition of the thresholds used. The issue of evaluating and respecting the reserved flows of Caledonian watercourses is crucial, particularly for the freshwater biodiversity compartment (inscribed in the PEPNC), in a context of political ambition to increase food self-sufficiency and therefore intensify agricultural production.

Soil erosion

Œil is in process of developing a mapping of the erosion figures in Province Sud, based on satellite images in 1976 and 2018, which will therefore not be a modelling exercise but a mapping analysis (pers. com. A. Bertaud). Once these data are available for the whole of New Caledonia, they will constitute a better indicator than the data produced by modelling, and will also make it possible to calculate the SESP in addition to the SES thanks to analysis on the image dating back to 1976.

Greenhouse gas

The territory's capacity to be accountable for these GHGs related to fire is an identified issue. Indeed, carbon release does not only depend on plant formation that burns but also on its level of desiccation (the same surface fire in the same place will not release the same amount of GHGs at the very beginning as at the end of a dry season).

Ozone depleting substances (ODS)

ODSs are not monitored in New Caledonia. They are not monitored by Scal'Air, and are not monitored in the CITEPA's "*Émissions de Polluants Atmosphériques*" (Air Pollutant Emissions) Inventory. The UNEP Ozone website that lists all emissions by country only produces an aggregated figure for France, and not for New Caledonia.

Terrestrial ecosystem pollution

In the European ESGAP (Gold standard), terrestrial ecosystem pollution indicators are derived from atmospheric concentrations of NOx, SO2, heavy metals, and ozone (tropospheric). Data on these pollutants are collected by Scal'Air, but are only available for Nouméa and part of Province Sud. This scope is therefore not representative of New Caledonia. Scal'Air has also carried out work on the regulatory thresholds, based on the WHO's recommendations and on French standards. For nickel (heavy metals), these standards are exceeded, due to the high nickel content in the New-Caledonian environment.

Moreover, the DIMENC has produced an analysis of pollutant emissions for New Caledonia, for 2008, 2010, and a forecast for 2030 (CITEPA, 2014). These data are not spatialized, but are described in detail for each sector of activity. No exceedance threshold is associated with these emissions. It is not possible to use the ESGAP Gold Standard method, which calculates the surface percentage of each country where the critical heavy metal, acidification and eutrophication thresholds are exceeded.

Marine ecosystem pollution

Little quantitative information exists for measuring the pollution of marine ecosystems, and we are unable to calculate an indicator within the framework of this report. This is first due to low physical or chemical anthropogenic pressure risks. As regards physical pressures, deep-sea fishing is practised by longliners that do not use techniques harmful to the environment, and that very rarely accidentally catch emblematic species. 48 sharks where thus released dead and 737 were released alive in 2018 (DAM, 2018).

No data exists on anchorages, although anecdotical mentions of destruction of sea beds due to cruise ship anchors have been reported.

As regards chemical pollution, two sources of information exist: measurements taken in water treatment plants, as well as certain individual measurements taken on the impact on the sea from mining activities. Oeil has been monitoring water bodies in Grand Sud since 2003 (Desoutter and Bertaud, 2019). Two obstacles prevent the creation of a good ecological state of water bodies indicator based on this monitoring. First, regulatory requirements are specific to each site and the reference state calculation is calibrated on certain watercourses not affected by man, which makes the creation of a homogeneous and systematic index complicated on the country scale. Then, monitoring data are not public and are not easily accessible.

A priori, no indicators exist on the influence of terrestrial tributaries that may come from former mining sites, agricultural activities, eroded areas, or infrastructures. Individual studies on biological indicators were carried out around mining sites (van Wynsberge et al., 2013; 2017). However, indicators representative of New Caledonia are not currently available. A guide for monitoring the marine environment was published by the CNRT (National Technology Research Centre on Nickel and its Environment) (Beliaeff et al., 2011), and is currently being revised. It proposes reference values for a number of physico-chemical, biological and ecological indicators.

A number of issues and indicators are mobilized for managing the Natural Park of the Coral Sea, in order to identify management issues, notably on the state of the environment (deep, open-sea, reef). However, no good state scientific objective, or regulatory objective is currently available (Gardes et al., 2014).

Terrestrial biodiversity

Given the multiple facets for characterizing terrestrial biodiversity, other indicators are developed worldwide and would be mobilizable in future versions of the ESGAP. Incidentally, it is recommended to use several of these indicators in order to have a complete picture of the biodiversity issues (WWF, 2018). On the local scale, the extremely precise mapping of forests by the IRD (Research Institute for Development), on behalf of Province Nord, would make it possible to develop indicators on the functionality of forests, notably on their fragmentations (Birnbaum et al., 2015). This fragmentation indicator would be more reliable, accessible and structuring for assessing the state of health of terrestrial ecosystems and mainly forest ecosystems. The assessment remains fragmented but focuses on one of the most critical aspects for Caledonian forest resilience, their connectivity. An IAC/CIRAD research project in collaboration with the IRD and Oeil, named DYNAMIC, aims to examine the evaluation of the fragmentation in Province Sud. However, fragmentation objectives will need to be defined.

On the global level, the UICN Red List (published by Endemia for plants in New Caledonia), is a conventional biodiversity indicator, which is included in the list of SDG monitoring indicators. However, it may be fairly bias, as it depends on the number of species that are included in its evaluation, and on the expert opinion methodology that is used to characterize the vulnerability of the species studied. In addition, this list does not mention the functional aspects related to ecosystems. The Species Habitat Index and the Living Planet Index developed by WWF are also two potential indicators on the global scale (WWF, 2018). These indicators measure other aspects of biodiversity, and use other thresholds.

The Living Planet Index measures the abundance of species monitored over time, with 1970 for reference (Loh et al., 2005). This is a macro-indicator that only takes into account the evolution of populations of vertebrate species from 1970 to the present day. It does not provide information on small geographical scales for which there would not be a sufficient naturalist dataset. Furthermore, it is not suitable for measuring the entire biodiversity as it does not take invertebrates and plants into account. The only subregion where a Living Region Index (LRI) was produced is the PACA region, thanks to the naturalist observation pressure that has existed in this region for a very long time (Galewski and Dragone, 2017). In addition, this indicator is not very sensitive because it is based on inventories of species that are not always carried out every year and with aggregated data transmission that takes 12 to 24 months. Therefore, the photograph given is not instantaneous. A regional definition of a LRI in New Caledonia would therefore not meet our needs and it cannot be calculated (C. Sourd, pers. comm.). In this family of biodiversity indicators, an annual monitoring of birds has existed for 10 years thanks to the SCO (New Caledonia Ornithological Society) initiative, the STOT[6] (temporal monitoring of land birds), but it would need to be extended further and continued in the future.

Aquatic biodiversity

A new diatomic index is in the process of being constructed to assess the good ecological state of New Caledonia's aquatic ecosystems (Marquié et al., 2017). Data from this monitoring are not yet available for constructing an indicator.

Drinking water pollution

Townhalls and water distribution operators (such as Calédonienne des Eaux), have monitoring data on the distribution network, but the data are fragmented and not aggregated by one single stakeholder. In spite of a great deal of feedback and reports provided on drinking water distribution and purification, we were not able to obtain a representative view of New Caledonia. Monitoring the quality of drinking water is one of the elements of the PEPNC, that we may know more about in the future. Many areas therefore need to be explored to strengthen the ESGAP dashboard and composite indicators in New Caledonia, which may be updated according to the availability of new data.

[6] https://www.sco.nc/mobiliser/suivi-temporel-des-oiseaux-terrestres-stot-nc-page-5111

PROBLEMS RELATED TO THE USE OF TIME SERIES

Calculating the SESP has been methodologically problematic. For the calculation of the BII used as terrestrial biodiversity indicator, the open access results of the model only concerned one year. It would be possible to obtain a time series by requesting this from the model's designers (A. Usubiaga, pers. comm.). However, we have not exploredthis option, notably because the results of the time series would come from an earlier version of the model, which would not be comparable with the results used for calculating the SES indicator in this report.

In the case of the freshwater pollution indicator, a time series is available for the IBS and IBNC indicators using methodologies earlier than those updated in 2016. No clear trend emerges graphically from these data, as the direction was different according to the reference period used (Figure 8). For example, the trend is positive (in green) if we take the 2010-2014 period, but negative if we take the 2014-2018 period. In some cases, it is recommended to use averages over several years rather than annual data in order to highlight trends. In this case, the variability is too great for this method to enable us to analyse the results.

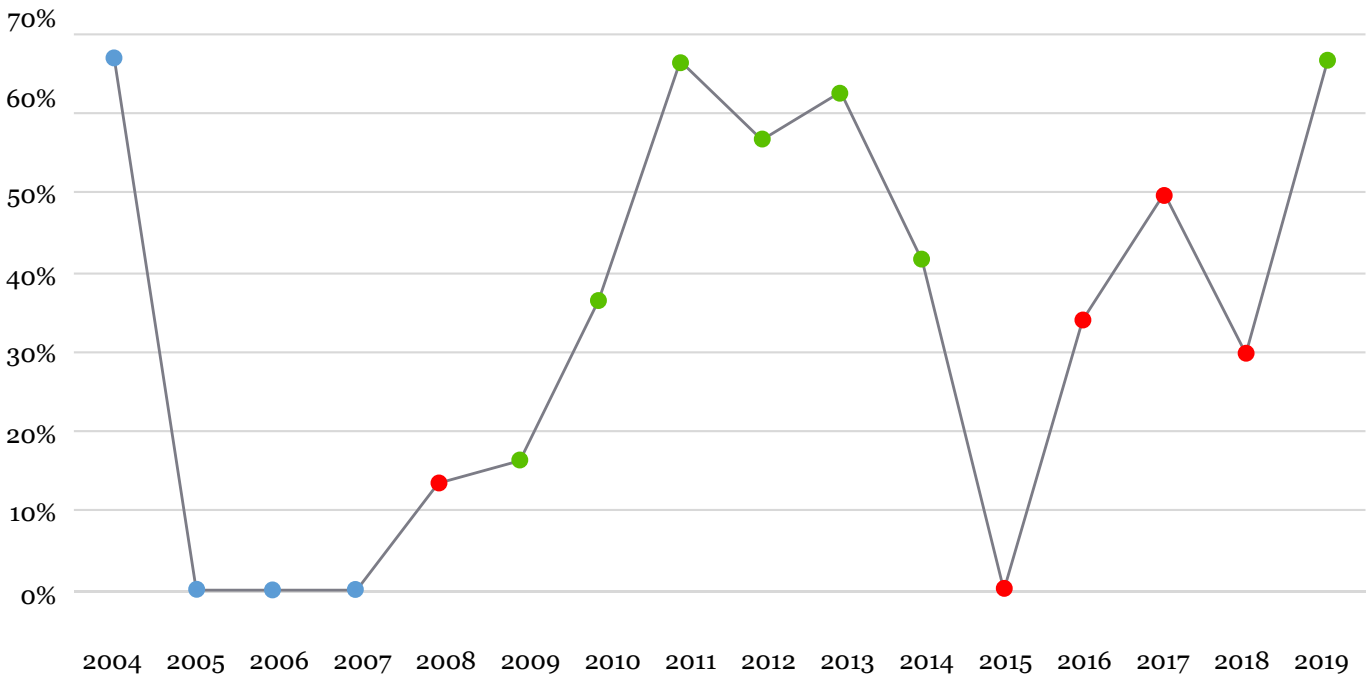

Figure 8. Percentage of stations measuring a "good" or "excellent" IBS and IBNC index.

Legend

- Positive trend over a 5-year period
- Negative trend over a 5-year period
- A 5-year period could not be calculated

2 - IMPLICATIONS FOR LOCAL PUBLIC POLICIES

The ESGAP dashboard is part of a strong sustainability context. Therefore, it can be used as an element of discussion for local public policies that aim to achieve biophysical targets.

The ESGAP dashboard is part of a strong sustainability context. Therefore, it can be used as an element of discussion for local public policies that aim to achieve biophysical targets. More and more public policies worldwide are aiming to achieve nature protection objectives that correspond to this strong sustainability issue. Achieving carbon neutrality, no net loss of biodiversity, or implementing the Avoid Reduce Compensate sequence for development projects can be cited. Other environmental policies focus on aspects not covered by the ESGAP, in particular, policies that set resource objectives (e.g. surface covered by a protection status), and those that set non-biophysical objectives (e.g. those that govern the energy mix).

In New Caledonia, two environmental public policies fall within the scope of the ESGAP: the New Caledonia Energy Transition Plan and the blueprint for a New Caledonia shared water policy (PEPNC). Apart from these public policies, regulations exist on the various human health and welfare indicators, including air pollution, bathing waters, and state of the UNESCO heritage. These regulations are subject to long-term monitoring that does not need to be specifically discussed here.

The New Caledonia Energy Transition Plan lists objectives in terms of energy mix and GHG emissions, with only GHG emissions falling within the scope of the ESGAP. For emissions, the objectives include reducing residential and tertiary sector emissions by 35%, mining and metallurgical sector emissions by 10%, and transport sector emissions by 15%, in relation to the emission forecasts related to consumption evolutions by 2030 (DIMENC, 2016). However, these objectives are not aligned with the Paris Agreement, of which France is the signatory. Moreover, GHG emissions have risen between 2005 and 2016 (last year for which data are available), which in addition is not in line with New Caledonia's current objectives (Figure 9). These data, produced by the DIMENC, are defined by sector of activity but are not disaggregated by province.

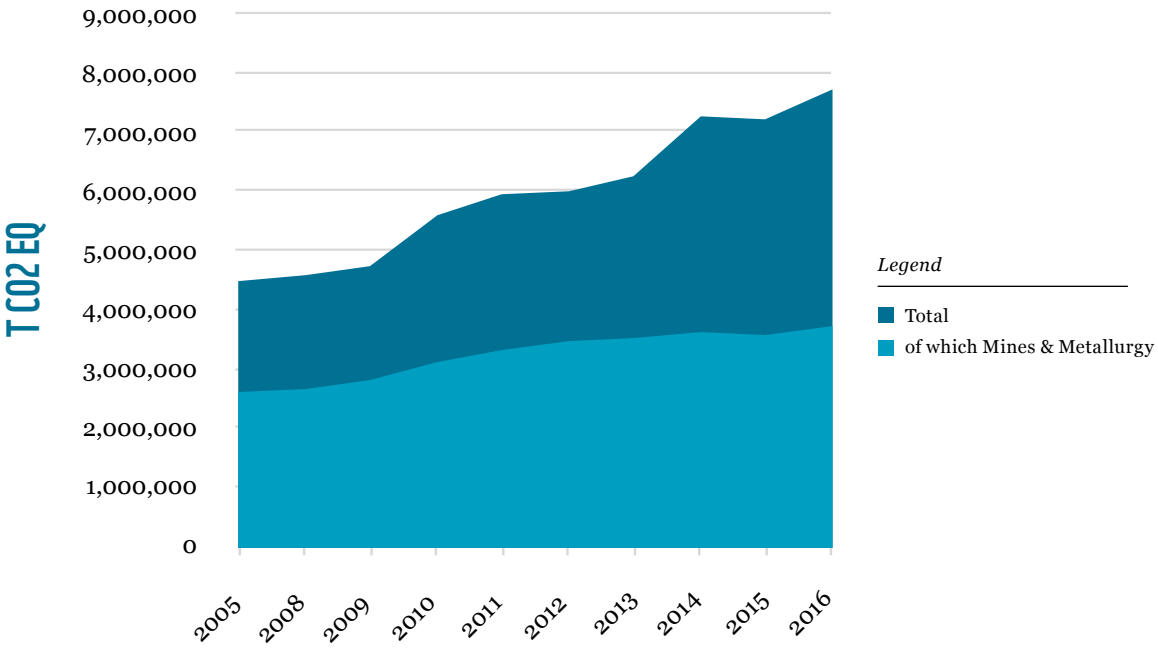

Figure 9. GHG emissions in New Caledonia. *Source: DIMENC, Direct GHG emissions in the "Climate Plan" format for New Caledonia*

The second major public policy for New Caledonia that falls within the scope of the ESGAP is the blueprint for a New Caledonia shared water policy (PEPNC). Several indicators concern water, in the four ESGAP functions. For the good state of aquatic environments, work is in progress to define standards but a European Union Water Framework Directive type approach would be difficult to implement in New Caledonia due to the difficulties in qualifying the reference states of each water body and due to access to the data (A. Bertaud, pers. comm.). One of the needs identified by the PEPNC is to put in place and consolidate water quality monitoring, but currently this monitoring has not yet been put in place (DAVAR, 2019). Our work confirms this need, as the collection of data has been hindered by the diversity of the stakeholders that collect water data, the absence of data storage centralization, the need to obtain authorizations to access and use existing data, and the fragmented sampling of water data.

The ESGAP indicators cover all aspects of the natural capital to be maintained for strong sustainability for New Caledonia. Therefore, it seems that many aspects are not yet covered by public policies that target achievement of the environmental objectives in New Caledonia, in particular regarding preservation of biodiversity, the sustainable exploitation of natural resources (excluding water), and the pollution of ecosystems.

3 - RECOMMENDATIONS FOR CONTINUED ENVIRONMENTAL MONITORING IN NEW CALEDONIA

The purpose of this report is a feasibility study on establishing the ESGAP dashboard and composite indicators in New Caledonia. Beyond this study, the question of the continued use of this tool for this territory arises. In this section, we address two important aspects that will influence possible continued use: (i) the continuation and extension of the collection of data used to develop indicators, (ii) the development of objectives and standards, and (iii) the use of this tool for environmental management.

CONTINUED ENVIRONMENTAL MONITORING AND DATA COLLECTION

The improvement in environmental data collection in New Caledonia is noteworthy in relation to other work carried out in the past on the establishment of New Caledonia sustainability indicators. For example, more indicators were able to be mobilized on the state of the environment in this study than for the 2006 National Biodiversity Strategy, for which a report on the environmental indicators was published by Œil and the DAFE (Department of Agriculture, Forestry and Environment) (Imirizaldu, 2010).

The three indicators mobilized in 2006 are "Evolution of the number of species inscribed on the UICN global red list", "Water quality", and "Fishing pressure". The indicator related to the UICN Red List has quantitative data in 2010, but was not retained as an ESGAP indicator. Indeed, the rise in number of species on the red list may quite simply mean that further effort is required in terms of evaluating the status of Caledonian species, and not that new species are threatened that previously were not.

For water quality, three data sources were identified: the DAVAR, Calédonienne des Eaux, and the DIMENC (responsible for ICPE), but only fragmented data could be obtained, and this only for the municipalities that gave their consent. Still today, we have come up against the same difficulties, which underlines the lack of progress on this theme, in spite of the PEPNC.

For the fishing pressure, only the evaluation of stocks by the SPC was available, as the Caledonian data on maritime fishing only includes the number of professional fishers, as no data are available with the provinces. New data on fishing are available on the government and province scale, with information on catches collected on a regular basis. In their current forms, these data cannot be mobilized in the ESGAP because they are not associated with any defined objective (such as achievement of the maximum sustainable yield for example).

The improvement in environmental data collection in New Caledonia is noteworthy in relation to other work carried out in the past on the establishment of New Caledonia sustainability indicators.

INDICATOR	DATA ARE REPRESENTATIVE OF THE NC	AVAILABLE IN PROVINCE SUD	AVAILABLE IN PROVINCE NORD	AVAILABLE IN PROVINCE DES ÎLES	DATA ARE SPATIALLY EXPLICIT	SOURCES
FOREST RESOURCES	X				No	FAO, DAFE
FISH RESOURCES	(X)	(X)	(X)		Only for DAM data	CPS, DAM, Provinces
SURFACE WATER RESOURCES	(X)	X			Catchments	Province Sud
GROUNDWATER RESOURCES						
SOIL EROSION	X	X	X		Yes, resolution 100m	UNC, Œil, Geoportal
GHG	X				No	DIMENC
ODS						
OZONE POLLUTION		X			Accurate modelling Nouméa	Scal'Air
HEAVY METAL POLLUTION		X			Accurate modelling Nouméa	Scal'Air
ACIDIFICATION POLLUTION		X			Accurate modelling Nouméa	Scal'Air
EUTROPHICATION POLLUTION		X			Accurate modelling Nouméa	Scal'Air
FIRE POLLUTION	X	X	X		Satellite data, variable resolutions	Œil
SURFACE WATER POLLUTION	(X)	(X)	(X)		Stations, watercourse segments	DAVAR, multiple
GROUNDWATER POLLUTION						
COASTAL AND MARINE ECOSYSTEM POLLUTION						
TERRESTRIAL FUNCTIONAL DIVERSITY	(X)				Low resolution global model	Sanchez-Ortiz et al., 2019
ECOLOGICAL STATUS OF FRESHWATER ECOSYSTEMS						
ECOLOGICAL STATUS OF COASTAL ECOSYSTEMS	X	X	X	X	Stations	Pala Dalik
INDOOR AIR POLLUTION						
OUTDOOR AIR POLLUTION	(X)	X			Stations	Scal'Air
DRINKING WATER POLLUTION	(X)				No	DAVAR
BATHING WATERS	X	X	X	X	Stations	DASS
UNESCO HERITAGE	X				No	UNESCO

Table 6. Spatialization of available data.

X Complete information (X) Fragmented information *(blank box)* Lack of information

This report has also highlighted the environ-mental objectives and issues that are not monitored in New Caledonia (Table 5). Indicators where no structured information is available could be priorities for action. These concern groundwater pollution and resources, marine environment pollution, and the state of freshwater ecosystems.

The distinctive feature of New Caledonia is the fragmented management of the various issues associated with the ESGAP. Spatializing data across the territory would make it possible to reconfigure the indicators in order to meet the environmental management issues at the appropriate administrative level. This spatialization does not call into question the framework and the methodology used by the ESGAP, but rather the data sources currently available in New Caledonia. Depending on the potential use of the ESGAP, several levels are therefore relevant. Complete spatialization of the indicators would permit aggregation on appropriate administrative levels according to the needs. The current state of data spatialization demonstrates that at the moment most indicators are not available at all administrative levels (Table 6). In these cases, work could be undertaken to (i) harmonize the databases and existing data collection protocols (e.g. for fishing data or use of forest resources), (ii) spatialize the data collected (e.g. for greenhouse gases), or (iii) extend existing monitoring to other levels (e.g. extend air quality monitoring to Province Nord).

Given the important aspect of ESGAP data spatialization, for calculating indicators and for possible adaptation of the ESGAP at various administrative levels, the DTSI (Department of Technology and Information Services) may also be an important stakeholder for storing and providing data useful for the construction of ESGAP indicators on its Geoportal. An issue regarding the construction of an integrated database resides in the collection and storage of heterogeneous data according to the stakeholders responsible for their monitoring.

CREATING ENVIRONMENTAL OBJECTIVES AND STANDARDS

A number of projects are in progress that could provide data for the ESGAP dashboard in New Caledonia in the future, notably work on the water quality benchmarks, and erosion monitoring (Section 5 part 1).

With regards to the state and pollution of marine environments, a CNRT guide of local thresholds was developed with expert opinions on an extremely comprehensive range of indicators (Beliaeff et al., 2011). However, this guide is intended first for evaluating the impact of the mining industry, and therefore is not representative of all situations in New Caledonia. This guide is currently being revised. Moreover, the Natural Park of the Coral Sea has a Management Plan[7], but the indicators for monitoring the implementation of this plan are still under construction. Biophysical indicators inspired by the ESGAP may therefore play a part within this framework.

A number of projects are in progress to develop environmental standards that may eventually replace (or confirm) the objectives used here, notably regarding water quality with the QAVAR project (UNC, CNRT).

USING THE TOOL FOR ENVIRONMENTAL MANAGEMENT IN NEW CALEDONIA

The continued use of this tool will also require it to be supported by one or more structures, which must make it possible to maintain the database necessary for the construction of ESGAP indicators over time and distribute the results to various stakeholders, notably within the framework of environmental public policy monitoring. Nevertheless, very few indicators used here are directly backed by public policies in New Caledonia, which may hinder its continued use and its political support.

The definition of areas of competence regarding environmental management and ESGAP functions in New Caledonia is complicated (Part 1). We have identified several types of structures as well as several administrative levels that would be the most relevant for supporting the ESGAP tool in New Caledonia. “Country” support of the ESGAP tool must be through a structure that would have the competence and legitimacy in the eyes of the local authorities to support and bring the tool to life.

Indicators where no structured information is available could be priorities for action. These concern groundwater pollution and resources, marine environment pollution, and the state of freshwater ecosystems.

[7] https://mer-de-corail.gouv.nc/fr/plan-de-gestion/le-plan-de-gestion-du-parc

The following three institutional stakeholders are all legitimate for supporting the implementation of the ESGAP: the *Service de l'Aménagement et de la Planification* (SAP - Department of Land Management and Planning), reporting to the General Secretariat of the New Caledonia Government, the *Direction du Développement Durable et des Territoire de la Province Sud* (Department of Territorial Sustainable Development of Province Sud) and the *Direction du développement écono-mique et de l'environnement de la Province Nord* (Department of Economic Development and the Environment of Province Nord). We were not able to meet with Province des Îles, but it could contribute in the same way as the other two provinces.

These indicators could contribute to the monitoring of the future Caledonian version of the post-2020 framework agreement of the Convention on Biological Diversity.

The main mission of the SAP is to create and coordinate the New Caledonia land management plan, approved at the Congress in 2016 (interview with Frédéric Guillard, department head, on 20/02/2020). This plan focuses on three main areas of work that are supported by the SAP: strategic planning, the establishment of land management contracts and the organization of observatories. Moreover, the SAP is currently working on the reporting of SDGs, a link that was made with the ESGAP indicators (Part 4 section 2).

Incidentally, in the same way that the ESGAP indicators could drive the analysis and report the achievement of SDG targets for the Caledonian government, these indicators could also contribute to the monitoring of the future Caledonian version of the post-2020 framework agreement of the Convention on Biological Diversity supported by the Convention on Biological Diversity. Adapting its reporting to New Caledonia could be supported by the *Direction du service d'Etat de l'Agriculture, de la Forêt et de l'Environnement* (DAFE Department of Agriculture, Forestry and Environment).

The Provinces, which have competence on many environmental issues, are also identified for continued use of the tool. They already carry out environmental monitoring, apply environmental codes and therefore play a key role in preserving the state of the environment and may be interested in monitoring its state and seeing the positive effects of public policies.

Adaptation of the tool must also take into consideration stakeholders' capacities to continuously and effectively support it, and at the right level. This is the case of two operators, Œil and the Conservatory of Natural Areas (CEN). The New Caledonia CEN is a Public Interest Group that does not have the delegation of the provinces to directly manage natural areas. The CEN coordinates management plans (dry deciduous forest, dugong, invasive species) and monitoring plans (corals, UNESCO world heritage), and reinforces the capacities of other stakeholders. It holds a significant institutional legitimacy on the country level, which makes it a potential stakeholder for supporting the ESGAP. However, its databases currently have a restricted focus on the themes that it deals with. However, the working group workshop currently carried out by all of its administrators on the future of the CEN may integrate the treatment of this ESGAP function.

The last most likely stakeholder is Œil, which is the environmental observatory for Province Sud. This stakeholder aggregates a large amount of environmental data in databases and produces it very much on an *ad hoc* basis. Œil was initially created to monitor the impacts of Vale NC but has extended is monitoring assignments. Thus, it currently operates in variable areas according to environmental themes. Œil has the capacity to carry out quality environmental monitoring and convey it in a format suitable for the various audiences. However, it does not yet have complete legitimacy to operate on the scale of New Caledonia, and is not yet supported by a stable funding mechanism. Discussions are underway between the Œil and the CEN to identify future collaborations.

One strategic aspect regarding support for the ESGAP, which has not been addressed in this report, is related to the assumption that the use of large quantitative databases is necessary – (or at least useful) as a decision support tool. It is possible that for quite a few subjects, environmental management involves other means of monitoring and discussion, notably for the customary bodies, and continuation of the ESGAP represents a cost and a cultural hindrance for some stakeholders.

On the regional scale, the SPREP's INFORM[8] project could be one of the support structures and ESGAP indicators developed for New Caledonia. The role of this project is to deconstruct the environmental data available on the Pacific scale, and distribute them via an Internet portal, in order to improve national and international decision-making.

[8] https://www.sprep.org/inform

The INFORM project could for example receive ESGAP indicator data in order to make them available through its portal.

Figure 10 attempts to summarize the issues of continuing the ESGAP in New Caledonia, on the one hand by linking the ESGAP functions and indicators to existing public policies (left side of the figure), and on the other hand to the organizations responsible for collecting environmental data and to the needs related to strengthening the tool (definition of environment objectives, creation or extension of data collection in space and time) (right side of the figure).

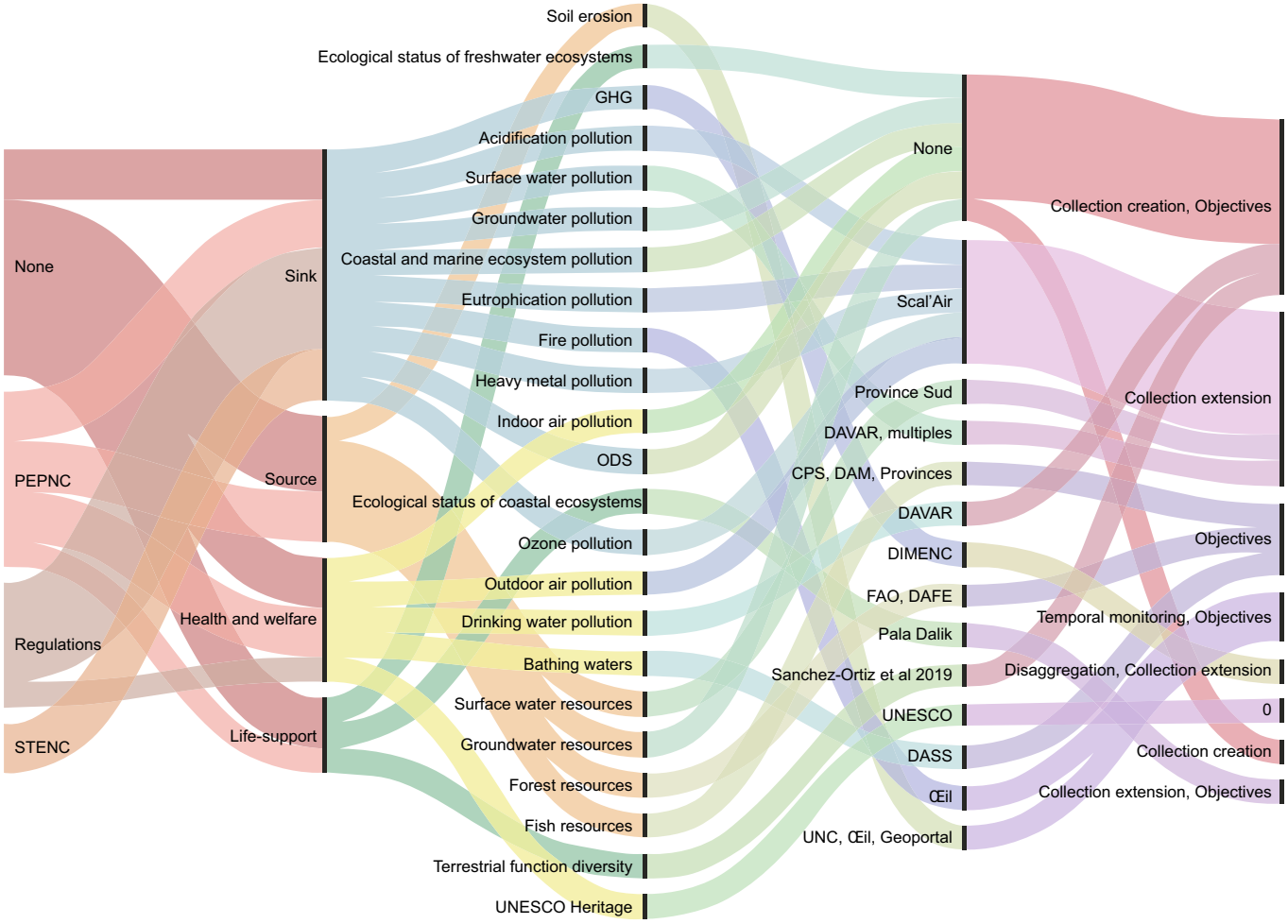

Figure 10. Links between public policies, ESGAP functions, the indicators constituting it, the organization responsible for collecting the data used, and recommended improvements for continuation of the tool.

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ECONOMIC APPLICATIONS

ESGAP ECONOMIC EXTENSIONS

As a dashboard grouping indicators on the state of the environment and pressures exerted on it, the ESGAP can be linked to economic data. Thus, Ekins et al. (2003) and Ekins, Milligan, and Usubiaga-Liaño (2019) envisage an extension of the ESGAP called Monetary ESGAP (M-ESGAP). This is an indicator that represents the cost for achieving a sustainability goal, in terms of pressure reduction costs and environmental restoration costs. This indicator is very similar to the national environmental accounting work carried out in the 1990s (United Nations 1993; Vanoli 1995; Statistics Netherlands, Bosch, and Brouwer 1997) and at the beginning of the 2000s (United Nations et al. 2003; Vanoli 2012). A second extension of the ESGAP related to economic analysis involves establishing the link with the economic sectors causing environmental pressures.

These two extensions have been tested on the New Caledonia scale. The first corresponds to the calculation of unpaid ecological costs (according to the name given by André Vanoli 2012, but with a different accounting integration). The second involved establishing a link with the New Caledonia strong sustainability economic diversity study carried out by (Vertigo Lab and Bio eKo Consultants 2020). Figure 11 describes the ESGAP's link with the two extensions presented.

As a dashboard grouping indicators on the state of the environment and pressures exerted on it, the ESGAP can be linked to economic data.

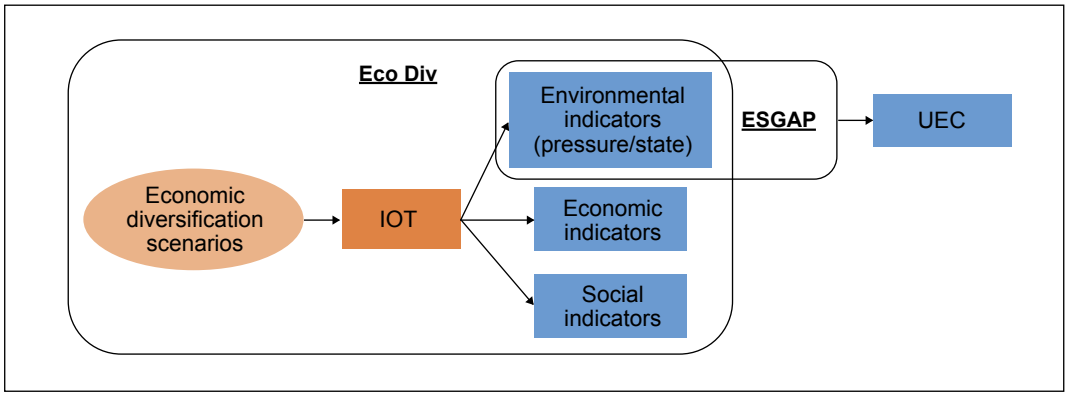


Figure 11. The ESGAP's link with its economic extensions.

Eco Div : New Caledonia strong sustainability economic diversification study.
IOT : Input-Output Table.
ESGAP : Environmental Sustainability Gap.
UEC : Unpaid Ecological Costs.

The IOT and the indicators may be calculated for one year. The impact of transition scenarios can then be modelled on the economic structure (IOT), the state of the environment (environmental indicators), certain economic summary characteristics (economic indicators) and social characteristics (social indicators). A physical summary on the environment is the ESGAP, and an economic summary on the environment is the UEC.

REALIZATION OF STRONG SUSTAINABILITY IN ECOLOGICAL TRANSITION SCENARIOS

The definition of strong sustainability given in the introduction, and from economic sciences, needs to be operationalized so that stakeholders can get to grips with it. This framework proposes several ideas within this context.

Economic activity that destroys natural objects (resources, ecosystems, etc.) in the aim of creating goods and services, inevitably leads to failing to achieve strong sustainability. This definition therefore needs to be more flexible. One sug-gestion is to only consider the critical natural capital, which is a limited part of the natural objects necessary for the

correct functioning of ecosystems and that make it possible to maintain value flows (Ekins et al. 2003).

Even by retaining a slightly more flexible definition of strong sustainability, it is still very difficult to achieve. Indeed, based on current knowledge, technologies and organization of the economy, managing to avoid replacing natural capital with economic capital requires significant transformations. On the other hand, the impacts of the economy on this capital can be reduced by following certain principles and aiming for well-defined normative objectives.

Thus, **strong sustainability economic diversification must be based on scenarios that aim to achieve environmental objectives that stipulate no degradation of various components of the environment** (biodiversity, climate, marine and terrestrial water quality, air quality, soil erosion, etc.) **beyond critical thresholds.**

Several avenues can then be explored, including the substitution of certain economic activities with others (which makes it possible to maintain a given employment level and GDP), the replacement of certain technologies or practices (land management, agriculture, industry, etc.) in order to reduce the environmental impacts of the activity if we want to keep a given activity or develop a new one, and lastly the restoration of the environment (biodiversity, carbon offset, water filtration, etc.) in some cases. The case of irreversible damage is separate: a strong sustainability trajectory does not permit such destructions. Although the damages are uncertain, a precautionary principle should be followed.

Thus, three types of costs (in the broad sense) and actions emerge: restoration expenses that some public or private stakeholders will have to bear; investments in new assets and learning processes; and opportunity and/or transition costs during the development of new "green" activities instead of "brown" activities.

Past activities have already caused a certain degree of environmental degradation, and it may be necessary to clear a past "ecological debt" by carrying out environmental restorations. Prior to that, it seems logical to reduce the current pressures. Only in a second stage shall we attempt to recover an environmental level equivalent to that of the objectives set based on a scientific reference, a past state, etc.

Given the state of the climate and biodiversity, the pressures exerted on them, and the current economic trajectories, radical measures must be implemented (first substitutions of activities, then marginal reduction of the impacts) in order to hope to get on track for strong sustainability.

1 - CALCULATING UNPAID ECOLOGICAL COSTS

Basically, the construction of unpaid ecological costs (UEC) may follow three main approaches. Each one is based on different sources. The more precise they are, the more stringent and realistic the measures.

The first approach starts with the state of the environ-ment. This involves using observations of environmental degradations, and using an average reduction or restoration cost. One or other of the actions will be selected based on how easy it is to obtain the data, this being related to the general plausibility of the measure (reduction for air emissions, restoration for water and ecosystems, etc.). It should be noted that this is not a specifically "macro" approach, but an approach that starts with observation of the environment and not the economy.

A second method, that is more stringent, is based on an inventory of the pressures exerted by each sector of activity and households. Based on this, the sector expenditure needed to reduce then, if this is not possible, offset damage to the environment is determined. Here, this involves a statistical approach, based on the extrapolation of pressures and costs occasionally observed with sectors or types of households that are considered as homogeneous.

A third strategy, that is more precise, involves studying the organizations and individual households rather than the sectors. Here, corporate environmental accounting (or surveys for households) are used that are aggregated and corrected in order to draw higher level conclusions. As shown by the construction of national economic accounts, the aggregation of this type of data requires the use of additional information for completeness (some sectors or types of companies are not taken into account), consolidation (corrections need to be made), and supplementing (some data are not measured in the accounting systems) purposes. Here, reduction and restoration measures are selected on the acting entity level, and the costs are budgeted expenditures. It is then possible to monitor the ARC (Avoid, Reduce, Compensate) sequence with a maximum likelihood.

Depending on the environmental themes, a combination more or less similar to one of these three approaches was followed here.

SELECTION OF THE INDICATORS RETAINED

Table 7 is a feasibility assessment based on the following elements: information acquired during the interviews, data collected in the field and in scientific literature. The themes cited in this table are those at stake or covered by regulations in New Caledonia. Therefore, data are more easily accessible for these subjects.

Legend

GHG The rows in bold are described in detail in the following subsections

The most difficult aspects for calculating UEC

(Surfaces) Data finally not been used

FUNCTION	INDICATOR	EXISTING BIOPHYSICAL DATA	MAINTENANCE OBJECTIVE	LINK WITH SECTORS OF ACTIVITY	REDUCTION MEANS AND COSTS	RESTAURATION MEANS AND COSTS	UEC CALCULATION
SOURCES	Forest resources	*(Surfaces, volumes of wood and fertility)*	Maintenance of productivity	Yes	NA	Unknown costs	Impossible
SINK	**GHG (Greenhouse gas)**	**GHG emissions**	**Carbon neutrality/voted objectives**	**Yes**	**Incompletes**	**Unknown**	**Impossible**
SINK	Surface water pollution	Annual mining Assess. (IBS and IBNC)	Regulatory thresholds	Partial	Unknown	Unknown	Impossible
SINK	Fire pollution	*(Burned surfaces)*	Unknown	Modelling	Known	Known	Impossible
HEALTH & WELFARE	**Air pollution**	**Pollutant emissions**	**Regulatory thresholds**	**Yes**	**Unknown**	**Unknown**	**Impossible**
LIFE-SUPPORT	**Destruction of habitats**	**Historical and ARC sequence (LU)**	**No net loss**	**Expert opinion**	**Unknown**	**Known**	**Done**

Table 7. Feasibility diagnosis for calculating UEC for various themes.

ARC : Avoid, Reduce, Compensate.
LU : Land Use.
NA : Not applicable

Three themes were finally retained to explore the construction of UEC: the destruction of ecosystems, greenhouse gas emissions, and pollutant emissions. They are described in detail in the following sections. Only the destruction of natural habitats led to a calculation. Here, it should be noted that this theme is redefined in relation to the biodiversity indicators retained in the ESGAP. Indeed, costs were only found for the restoration of terrestrial ecosystems. There is no direct link with the *Biodiversity Intactness Index* used as an ESGAP indicator and no coral reef restoration costs were found. The other themes could not be explored in detail due to the lack of very important data. They are briefly described below.

UEC may be calculated for renewable resources. For example, in accordance with the System of Environmental-Economic Accounting (SEEA) (United Nations et al. 2014) and with the method described by the World Bank, Bartelmus (2009) performs this calculation using the income from unsustainable forest exploitations. This approach is of interest because it does not correspond exactly to unpaid ecological costs as defined above. UEC would mainly be calculated by adding up the replantation costs and possibly the nutrient supply costs in order to maintain a yield that is constant[9]. In our study, important data are missing (volumes of wood extracted by production type, observation of soil fertility, etc.). In addition, no costs for restoration or reduction of impacts could be used.

Surface water pollution is subjected to regulatory monitoring by the major mining companies. Therefore, detailed data exist on the micro level. However, the costs for reducing these pressures or restoring this environment could not be obtained.

Fires are a central theme in New Caledonia (interviews with Œil, on 24/02/2020 and with Hubert Géraux, manager of WWF NC, on 03/03/2020). Burned surface data has existed for many years. Pressure reduction costs exist because fire prevention expenses are known. The costs for restoring the terrestrial environments impacted are also known. However, the effort to combat fires is determined by an annual budget to be spent and whether or not to intervene is determined according to the level of risk of each fire (risk for humans, for infrastructures or for the natural environment). There is no real institutional maintenance objective. An objective for the number of outbreaks of fires or burned surfaces per year could possibly be targeted but such an objective could not be found here. Lastly, calculating the costs for achieving a given objective is a complicated exercise that would require specific interviews with specialist experts.

[9] Bartelmus assumed that the extra income was equal to these costs, which is not necessarily true, especially since there is no guarantee that the market price would not increase significantly if UEC were taken into account and made public.

DETAILED CLIMATE PLAN CODE	2005	2016
1-1 Electricity generation for metallurgical sites	941,933	2,463,328
1-2 Combustion - metallurgy of which NRMM	512,141	701,069
1-3 Processes, ore treatment and nickel production	307,796	741,736
TOTAL PC1 - Metallurgy	**1,761,870**	**3,906,132**
2-1 Electricity generation for the mining industry	13,788	8,230
2-2 Extraction and combustion in the mining industry of which NRMM	75,035	70,139
2-3 Road transport - Heavy-duty vehicles	16,537	21,914
2-4 Transport of ore carriers	18,756	23,975
TOTAL PC2 - Mines	**124,116**	**124,259**
3-1 Energy industries - Electricity generation dedicated to public distribution	378,393	781,026
3-2 Manufacturing industries - Combustion of which NRMM	72,717	239,537
3-3 Manufacturing industries - Industrial processes	3,464	13,827
TOTAL PC3 - Other industries	**454,573**	**1,034,390**
4-1 Air - National	13,608	17,717
4-2 Road	613,997	570,485
4-3 National maritime - Commercial traffic (excluding mines) and pleasure-boating	36,460	43,392
4-4 Fluorinated gases in transport	8,873	10,777
TOTAL PC4 - Transport	**672,938**	**642,371**
5-1 Tertiary	8,107	14,629
5-2 Residential	41,392	32,827
5-3 Other emissions remaining	8,890	17,077
TOTAL PC5 - REMAINING	**58,389**	**64,533**
6-1 Energy consumption	516,941	840,708
6-2 Enteric fermentation	38,222	29,782
6-3 Animal droppings	14,661	13,270
6-4 Agricultural soils	25,187	21,272
6-5 Burning of crop residues	-	-
TOTAL PC6 - Agri/silvi/fishing	**595,011**	**905,032**
7-1 Disposal on land	124,978	293,595
7-2 Composting	-	2,953
7-3 Wastewater	22,597	20,845
TOTAL PC7 - Waste treatment	**147,575**	**317,393**
8-1 Storage and distribution of solid fuels	-	-
8-2 Storage and distribution of liquid fuels	-	-
TOTAL PC8 - Fugitive fuels	**-**	**-**
9 - Land use, Land Use Change and Forestry	661,172	722,072
TOTAL PC9 - LULUCF	**661,172**	**722,072**
10 - Other uses of products	27	1,799
TOTAL PC10 - Other emissions	**27**	**1,799**

Table 8. Sectorial GHG emissions in FNC format.

Greenhouse gas emissions

The biophysical data used are the sectoral emissions of GHG. They were estimated by the DIMENC and the CITEPA in 2012. Two tables are used, one classifying the emissions according to the CRF (Common Report Format) activity typology and the other according to a typology specific to New Caledonia. The gases studied are specific to the activities and notably include the following: CO2, CH4, N2O and fluorinated compounds. Table 8 gives, by way of example, the 2005 and 2016 emissions.

The maintenance objectives available are the following:

- trajectory compatible with a global temperature rise of 2°C
- New Caledonia carbon neutrality
- objectives of the New Caledonia Energy Transition Plan (STENC):
  - Reduce CO2 emissions in the residential and tertiary sectors by 35% in relation to the trend forecast for emissions in 2030
  - Reduce emissions in the mining and metallurgical sector by 10% in relation to the trend forecast for emissions in 2030
  - Reduce emissions in the transport sector by 15% in relation to the trend forecast for emissions in 2030

The first objective is difficult to use due to the allocation of a carbon budget to the territory. Indeed, this point is the subject of much debate due to historical emissions and unequal reduction costs.

The carbon neutrality objective is attractive due to its simplicity but is a long way from New Caledonia's current economic and political processes. Indeed, the STENC defines greenhouse gas reduction objectives that are not very restrictive because they are constructed in reference to the emissions trajectory for 2030 (the objective therefore accepts that emissions will continue to increase in relation to now) and only concerns specific sectors. Even so it is useful to retain this neutrality objective because it makes international comparisons easy.

The allocation of emissions to the sectors of activity in the IOT was possible by way of a limited number of assumptions. The results are presented in Table 9.

SOURCE	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016
PUBLIC ADMINISTRATIONS	782	721	1,241	1,264	1,222	1,185	1,275	1,468	1,533	1,466
AGRICULTURE, HUNTING, SILVICULTURE, FISHING, FARMING	595,011	693,209	768,858	821,198	906,797	981,827	834,479	902,243	843,939	905,032
BANKS AND INSURANCE COMP.	237	238	420	431	414	393	420	482	516	506
BUILDING AND PUBLIC WORKS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TRADE	2,782	2,407	3,948	3,971	3,777	3,659	3,886	4,502	4,669	4,479
ENERGY	309,139	265,096	257,645	180,412	201,747	184,324	186,000	247,888	207,948	255,824
MISCELLANEOUS INDUSTRIES	249,173	408,987	437,899	695,164	755,226	787,623	963,626	933,455	948,248	1,016,721
NICKEL INDUSTRIES	1,853,442	1,889,136	1,844,062	2,451,878	2,561,388	2,487,572	2,700,091	3,595,184	3,626,980	3,998,185
BUSINESS SERVICES	1,884	1,770	3,108	3,174	3,086	3,055	3,386	3,906	4,002	3,885
HOUSEHOLD SERVICES	54,668	57,819	67,715	76,589	84,793	93,294	99,074	103,297	107,770	110,920
TRANSPORT AND TELECOMMUNICATIONS	678,114	527,685	591,785	598,474	615,942	618,614	613,296	623,488	649,961	649,492
HOUSEHOLDS	57,808	58,451	53,320	53,820	53,007	54,560	52,013	50,085	52,428	51,638
TOTAL	**3,803,040**	**3,905,519**	**4,029,000**	**4,886,374**	**5,187,398**	**5,216,104**	**5,457,545**	**6,465,998**	**6,447,994**	**6,998,147**

Table 9. GHG emissions by sector of activity. Building and public works emissions were not estimated in the source data.

Research has been carried out to determine **reduction or restoration costs** (carbon storage). Unfortunately, neither the on-site interviews nor research in the literature have made it possible to find technical reduction costs for the sectors of activity concerned. Macro-reduction costs, from modelling (Quinet et al. 2019; 2009), exist but cannot be transposed to New Caledonia whose economy is very different from Metropolitan France (energy mix, weight of the mining-metallurgical sector, radically different import levels).

Other air polluant emissions

The biophysical data used are the sectoral emissions of air pollutants. Two sources are used. The first is an air emission monitoring network (Scal'Air 2019). The second source is the emissions inventory carried out for the DIMENC (CITEPA 2014).

The Scal'Air monitoring network monitors the air quality through 4 stations in Greater Nouméa and 5 stations in Grand Sud, around the New Caledonia Vale installations. The pollutants included in an annual report are SO2, NO2, ozone, fine particles (PM10 and PM2.5), polycyclic aromatic hydrocarbons, heavy metals and pollens. The data are presented in mean annual concentrations between 2014 and 2018.

The maintenance objectives used are the applicable regulatory thresholds for health. All of the target values are met with the exception of nickel. Nickel is therefore the only value for which unpaid ecological costs may be calculated (for the others, the current environmental expenditure is sufficient). The mean concentration of nickel in the air exceeds the target value of 20 ng/m3 every year except for 2015 for Greater Nouméa. In order to remain below this level, emissions need to be reduced by 35 to 40%. For the Grand Sud, the target value was only exceeded in 2015.

The DIMENC inventory was used to establish the **link with the sectors of activity**. It keeps account of the pollutants relating to acidification, eutrophication and photochemical phenomena, heavy metals, dust, persistent organic pollutants (8 polycyclic aromatic hydrocarbon categories) and benzene for NFR (Nomenclature For Reporting) type sectors of activity. The results are given in tonnes per year for the following years: 2008, 2010 and an estimate for 2030.

Nickel emissions for 2010 are given in Table 10.

SECTOR	NI EMISSIONS (KG/YEAR) IN 2010	PROPOR-TION
FSN 1 - Metallurgy	9,534	85%
FSN 2 - Mines	176	2%
FSN 3 - Industries (excluding metallurgy and mines)	1,561	14%
FSN 4 - Transport	5.42	0%
FSN 5 - Residentiel Tertiary Institutional and Commercial	0.02	0%
Total emissions in 2010	**11,275**	**100%**
FSN 10 - (here: mainly international maritime)	4,505	

Table 10. 2010 nickel emissions in FSN format

No **reduction cost** could be found for calculating UEC for nickel. A synthesis project including the cost of a number of air pollution reduction measures was carried out in Metropolitan France within the framework of the French national air pollutant emission reduction plan (CITEPA et al. 2016). However, it does not include costs concerning nickel or the mining and metallurgical sector, which in our example is the main target of the measures. Therefore, it was not possible to calculate UEC for this theme.

Destruction of habitats

The destruction of ecosystems is measured based on two source data: on the one hand, the areas historically destroyed for mines (prior to 2009 and amendment of the Mining Code) and today managed by Fonds Nickel (Nickel Fund), and on the other hand those that are subjected to the Avoid-Reduce-Compensate (ARC) sequence since 2009 for mines or since 2015 for land management projects. The ARC sequence is dealt with by the Provinces.

Historical mining destruction concerns forest areas in the mountain region of Grande Terre. These

The mean concentration of nickel in the air exceeds the target value of 20 ng/m3 every year except for 2015 for Greater Nouméa. In order to remain below this level, emissions need to be reduced by 35 to 40%.

areas are the subject of a restoration programme managed by Fonds Nickel (the figures given below come from an interview with Thomas Leborgne, Fonds Nickel Policy Officer and Jean-Sébastien Baille, Deputy Director of the *Direction de l'Industrie, de la Mine et de l'Energie de Nouvelle-Calédonie* (DIMENC), on 21/02/2020). It was given 1.7 billion CFP francs (approximately 14 million euros) upon its creation in 2009 and every year receives surface fees from mining concession holders. The fees were 245 million CFP francs in 2009 and 230 million CFP francs (approximately 1.9 million euros) in 2020.

Destructions related to the development of mines in New Caledonia are estimated at a total of approximately 20,000 ha, since their emergence, mainly during the 1976 mining boom. If the natural capital maintenance objective is considered with regard to the ecological state of natural habitats before the emergence of mines, then the ecological debt (UEC) needs to be calculated based on the total cost of the ecological offset of these 20,000 ha. This value constitutes a "historic" objective that can be qualified as "pristine" (*cf.* Figure 2).

Destructions related to the development of mines in New Caledonia are estimated at a total of approximately 20,000 ha, since their emergence.

SECTOR OF ACTIVITY	PRESCRIBED COMPENSATION	COMPENSATION ACHIEVED	COMPLETION RATE
Mines	1,328 ha	82.1 ha	6%
Vale	438 ha		
SLN	106 ha		
NMC	62 ha		
SMGM	35 ha		
Farming or forestry	137 ha	0.0 ha	0%
Urban planning	26 ha	1.1 ha	4%
Quarries	24 ha	0.8 ha	3%
Structures/ buildings related to public equipment	10 ha	0.5 ha	5%
Wind farm	5 ha	0.0 ha	0%
Road infrastructures	3 ha	0.2 ha	8%
Total	**1,533 ha**	**84.6 ha**	**6%**

Table 11. Surfaces destroyed and compensated under the ARC sequence between 2009 and 2018 *(source: Nicolas Rinck)*

A second benchmark that can be used is that of the offsets that can be achieved with regard to technical constraints in the field. Thus, based on expert evaluation work, Fonds Nickel estimates that it is "technically" possible to restore around 6,500 ha, the rest being "vertiginously high embankments or inaccessible areas". Hypothetically, these remote habitats could be restored, but by mobilizing much more onerous resources and techniques that do not yet exist.

Figure 2 mentions another type of objective, the political objectives. What becomes most apparent in this study are the objectives of Fonds Nickel's multi-year rehabilitation programme, which are approved by the New Caledonia Congress. Thus, the current plan targets 1,135 ha. However, it is likely that the objective of 6,500 ha will be approved "bit by bit" in the next multi-year plans, and that it will be achieved within the next 20 years. In all likelihood, the so-called "political" and "technical" objectives will therefore coincide. Therefore, no distinction will be made between the two here.

More precisely, since 2009, 1,500 ha have been the subject of work by Fonds Nickel. This work is of two types: watercourse rehabilitation (with the primary objective of restoring flows, reducing risks for populations and structures) and revegetation work. Work needs to be carried out on watercourses in order to subsequently be able to replant certain areas. The cost of watercourse rehabilitation is on average 660,000 CFP francs/ha. The average cost of revegetation work is 8 million CFP francs per hectare (approximately €67,000/ha). Fonds Nickel invests as much in each type of work. Thus, in addition 140 ha of the 1,500 ha that benefited from watercourse rehabilitation, were able to be revegetated. The ecological debt is considered as entirely settled when the two types of work have been completed.

As for the ARC sequence, it is applied to any mine development, urban planning, ICPE, or clearing project, or if it affects ecosystems of heritage interest (Biotope et al., 2016, p. 30).The habitats involving compliance with the ARC sequence (impact study and ecological offset) correspond to any type of habitat: forests, open areas, mangroves, reefs, etc. The impacts are broken down between various sectors of activity (Table 11; source: interview

				RETURN TO HISTORICAL STATE			ACHIEVABLE AND POLITICALLY APPROVED		
TYPE OF IMPACT	SURFACE DESTROYED	SURFACE RESTORED	UNIT COST	OBJECTIVE	UEC (FRANCS)	UEC (€)	OBJECTIVE	UEC (FRANCS)	UEC (€)
Mining history	20,000 ha	140 ha	8 M XFP	19,860 ha	NA	NA	6,500 ha	52,000 M XFP	€437 M
ARC sequence	1,533 ha	85 ha	8 M XFP	1,448 ha	11,587 M XFP	€97 M	1,448 ha	11,587 M XFP	€97 M
Total	**21,533 ha**	**225 ha**	-	**21,308 ha**	**NA**	**NA**	**7,948 ha**	**63,587 M XFP**	**€534 M**

Table 12. UEC calculations related to the destruction of habitats *(source: interviews)*

with Nicolas Rinck, ARC sequence policy officer at Province Sud, on 24/02/2020). It can be seen that mining is by far the main sector impacting habitats. Unlike the case of historical legacy, concerning the ARC sequence, the so-called historical, political or technical objectives (*cf.* Figure 2) coincide with the 100% restoration value. Therefore, only one objective is retained for calculating UEC.

It is noted that 94% of the surfaces destroyed still need to be compensated. In all likelihood, this figure is higher in reality because not all of the files being handled have been included. The cost of forest ecosystem restoration work is the same as that of Fonds Nickel's work (same techniques), i.e. 8 million CFP francs. We are using this value for all of the surfaces affected as we were unable to obtain restoration costs for the other types of habitats.

Table 12 shows the UEC calculations.

Unpaid ecological costs concerning the destruction of habitats therefore amount to a minimum of 63.6 billion CFP francs, i.e. approximately 543 million euros. To get back to a true state before the beginning of the mining activity, the unpaid ecological costs would be significantly higher. We were not able to estimate them because the techniques for carrying out this work are extremely complicated and *a priori* very expensive. They have not been identified by local stakeholders.

63,6 BILLION CFP FRANCS

(543 millions euros) unpaid ecological costs concerning the destruction of habitats.

2 - LINK WITH THE ECONOMIC DIVERSIFICATION STUDY

This section deals with the work synthesis related to creation of the ESGAP. It aims to establish the link with the study on the New Caledonia strong sustainability economic diversification potential (Vertigo Lab and Bio eKo Consultants 2020). It is the result of a collaboration with Vertigo Lab and Bio eKo Consultants.

THEORETICAL LINK

The New Caledonia strong sustainability economic diversification study (Vertigo Lab and Bio eKo Consultants 2020) constitutes prospective work based on workshops and interviews with stakeholders in key ecological transition sectors. The creation of a New Caledonia economic model has been made possible thanks to these exchanges as well as important bibliographical work based on an Input-Output Table describing the links between the various economic sectors. After describing how the scenarios are developed and the model used by the New Caledonia strong sustainability economic diversification study, we will describe the links between the indicators produced by this study and the ESGAP indicators.

Scenarios for developing certain sectors aiming for a sustainable economy have thus been put forward and are then used in their modelling. Thus, we seek to understand the effects of these scenarios on the model's output indicators (economic, environmental, social). In order to create strong sustainability scenarios, the study may propose several types of changes such as:

- The development of environmentally-friendly sectors (so-called "green" sectors), from changes in practices in relation to current sectors: ecotourism, agroecology, renewable energy for example. Sustainability will only be guaranteed if these sectors replace equivalent activities that are not environmentally friendly (so-called "brown" because they overexploit resources, contaminate or destroy the environment. This assumes defining scenarios to scale back other activities, otherwise activities will probably simply be added.
- The implementation of reducing pressures for specific sectors of activity that produce particularly greater environmental impacts (mines, buildings, conventional agriculture, etc.)
- The development of an environmental restoration sector (ecological engineering, water pollution control, carbon offset, etc.) for residual impacts and possibly those accumulated in the past. This could also make it possible to develop nature-based solutions.

The link between the various possible actions (substitution of activities, reduction or restoration), requires work itself because several paths may potentially lead to sustainability.

The core of the model used is an input-output table. As the ISEE's data is highly aggregated, this table needs to be disaggregated in order to show more precise sectors of activity. This notably highlights the sectors that potentially need to operationally reduce or increase their environmental impact. The scenarios, which represent changes to the economy, may be modelled in two ways:

- Through the emergence of "green" sectors of activity, which may either be carried out by modifying the technical coefficients of a "brown" sector" (this option is equivalent to incremental changes in practices), or by changing the volume of products between a "brown" sector to its "green" equivalent (this option corresponding to the emergence of a sector of activity that is sufficiently different "green" in order to be identified as such; it has technical coefficients different from its "brown" equivalent; the volume transfer equates to an increase in market share).
- Through final demand impacts for given sectors of activity (e.g. "green" sectors") that reflect the choice of end consumers.

Three types of output indicators are monitored to evaluate the scenarios: economic, environmental and social. As social indicators are not linked to the ESGAP, we will not develop their functioning.

The economic indicators may be fairly simple and very much integrated into the economic module (growth rate, multiplier coefficients, import tax, etc.). They constitute advocacy (multiplier coefficients) or decision support (import level) indicators.

As regards the environmental indicators, a first approach is to add environmental pressure indicators for each sector of activity. This is what is currently being done (Vertigo Lab and Bio eKo Consultants 2020). An evolution of their level of activity is directly translated by impacts on the state of the environment that can be read and analysed as regards the social and economic indicators. We could also go one step further than simple measurement of the pressures by using the ESGAP. Thus, it would be possible to add an environmental objective for each pressure and calculate the difference between the trajectory for achieving this objective and the current trajectory of the pressure, then aggregating them, in order to obtain the "Strong Environmental Sustainability" (SES) composite indicator. Using ESGAP indicators as environmental indicators for the economic diversification study would require a fairly broad volume of data. Thus, we would have to be able to make the link between sector of activity-pressure-state of the environment (as opposed to a simplified sector-pressures approach, as is the case for the New Caledonia strong sustainability economic diversification study). The indicator's coverage is also extremely broad (climate, biodiversity, water, soil, etc., challenges).

An additional level of analysis may be added in the following way: the study specifies that the sector of activity-pressure link would make it possible to deduce other economic indicators such as the unpaid ecological costs, similar to the Monetary ESGAP. Basically, they correspond to the total expenditure for restoration, reduction and prevention of the impacts in order to achieve the environmental objectives. This indicator would be particularly enlightening in terms of the pressure reduction and environmental management decision. It would not only make it possible to know and control private and public expenditure, key elements for understanding the distributional effects (losing and winning) of any public policy, but also to budget actions. The calculation of this indicator may also shed light on which change tools (taxes or subventions, regulations, etc.) to choose.

REAL LINK

Finally, three potential coupling points have emerged and are developed in the following subsections:

- The environmental themes identified as priority and measurable;
- The environmental objectives;
- The links between the sectors of activity and the pressures on specific environmental functions.

Legend

Air Values studied quantitatively Water Values analysed qualitatively

ESGAP PRINCIPLE	ESGAP ISSUE	ECODIV CATEGORY	ECODIV ISSUE
Renewal of renewable resources	Forest resources	Natural resources	Renewable resources
	Fish resources		
	Surface water resources		
	Groundwater resources		
Reasonable use of non-renewable thresholds	Soil erosion	Natural resources	Non-renewable resources
Respect the critical pollution thresholds	Freshwater ecosystem pollution (IBNC+IBS)	Water	Chemical pollution
	Coastal and marine ecosystem pollution		
Respect the standards for human health	Drinking water pollution		
	Bathing waters		
Respect the critical pollution thresholds	Freshwater ecosystem pollution (IBNC+IBS)	Water	Biological pollution
	Coastal and marine ecosystem pollution		
Respect the standards for human health	Drinking water pollution		
	Bathing waters		
Prevent climate change	GHG	**Air**	**GHG emissions**
	ODS	**Air**	**Air emissions**
Respect the standards for human health	Indoor air pollution		
	Outdoor air pollution		
Respect the critical pollution thresholds	Ozone pollution		
	Heavy metal pollution	Soils/natural habitats	Chemical pollution
	Acidification pollution		
	Eutrophication pollution		
	Fire pollution		
Conserve landscape and amenities	UNESCO Heritage	Soils/natural habitats	Landscape insertion
Maintenance of biodiversity	Terrestrial functional diversity	Soils/natural habitats	Biodiversity
	Ecological status of freshwater ecosystems		
	Ecological status of coastal ecosystems		
	Distributed in the "Maintenance of biodiversity" categories	Soils/natural habitats	Biological pollution
NA	NA	**Water**	**Waste**
NA	NA	Air	Noise pollution
NA	NA	Soils/natural habitats	Land take
NA	NA	Soils/natural habitats	**Waste**

Table 13. Overlap of environmental themes between the ESGAP and the New Caledonia strong sustainability economic diversification study.

Environmental themes retained

A certain number of separations exist between the themes studied in the two projects (Table 13).

In many cases, the ESGAP indicators are more detailed than the New Caledonia strong sustainability economic diversification study. Thus, renewable resources are broken down by type. Similarly, the chemical and biological pollution of water is broken down by type of ecosystem (marine or freshwater) but also in relation to its impact on humans. Terrestrial ecosystem and air pollution is listed by type of pollutant. Lastly, biodiversity maintenance is defined by type of ecosystem.

Last but not least, the New Caledonia strong sustainability economic diversification study has a broader scope than the ESGAP in the selection of its themes concerning pressures on the environment: thus it explicitly includes waste, noise pollution, and land take.

Objectives

At this stage, the authors of the New Caledonia strong sustainability economic diversification study explain that the current political objectives must be monitored, without adding maintenance objectives that are more restrictive and/or consistent with scientific ecological boundaries, such as developed in the ESGAP. Objectives by sector from workshops have been identified but at this stage are not integrated into the transition scenarios.

SOURCE	2005	2008	2009	2010	2011	2012	2013	2014	2015	2016
PUBLIC ADMINISTRATIONS	782	721	1,241	1,264	1,222	1,185	1,275	1,468	1,533	1,466
AGRICULTURE, HUNTING, SILVICULTURE, FISHING, FARMING	595,011	693,209	768,858	821,198	906,797	981,827	834,479	902,243	843,939	905,032
BANKS AND INSURANCE COMP.	237	238	420	431	414	393	420	482	516	506
BUILDING AND PUBLIC WORKS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TRADE	2,782	2,407	3,948	3,971	3,777	3,659	3,886	4,502	4,669	4,479
ENERGY	309,139	265,096	257,645	180,412	201,747	184,324	186,000	247,888	207,948	255,824
MISCELLANEOUS INDUSTRIES	249,173	408,987	437,899	695,164	755,226	787,623	963,626	933,455	948,248	1,016,721
NICKEL INDUSTRIES	1,853,442	1,889,136	1,844,062	2,451,878	2,561,388	2,487,572	2,700,091	3,595,184	3,626,980	3,998,185
BUSINESS SERVICES	1,884	1,770	3,108	3,174	3,086	3,055	3,386	3,906	4,002	3,885
HOUSEHOLD SERVICES	54,668	57,819	67,715	76,589	84,793	93,294	99,074	103,297	107,770	110,920
TRANSPORT AND TELECOMMUNICATIONS	678,114	527,685	591,785	598,474	615,942	618,614	613,296	623,488	649,961	649,492
HOUSEHOLDS	57,808	58,451	53,320	53,820	53,007	54,560	52,013	50,085	52,428	51,638
TOTAL	**3,803,040**	**3,905,519**	**4,029,000**	**4,886,374**	**5,187,398**	**5,216,104**	**5,457,545**	**6,465,998**	**6,447,994**	**6,998,147**

Table 14. GHG emissions by New Caledonia IOT sector of activity. The building and public works emissions are missing from the source data. *Data: DIMENC, treatment: authors*

Sector of activity-pressure link

The data collected have made it possible to establish a minimum quantitative link on only one theme - greenhouse gas emissions. For this, we allocated greenhouse gas emissions to the sectors of activity and households in the New Caledonia Input-Output Table (IOT). This allocation was done with the IOT with 12 sectors but not with the IOT with 64 sectors created by Vertigo Lab, due to the lack of detailed information on GHG emissions (confidential information).

The allocation is based on the definition of the categories used in the inventories in New Caledonia and on that of the ISEE. Three cases were presented: the categories corresponded perfectly; certain sectors of activity included several categories of the inventories; certain categories of the inventories were split into several sectors of activity. A table for switching between the CRF (GHG emissions) and NAF (sectors of activity) formats (European Commission and Eurostat, 2015) was used as a basis for the work. Additional information on the definition of the "waste" and "maritime transport " categories was sent by the DIMENC. Lastly, employment data was used to distribute the emissions of the "Commerce/Institutional" category to public administrations, banks and insurance companies, commerce, corporate services, households, and transports and telecommunication. Table 14 gives the emissions for the available years.

As we had no access to the Vertigo Lab model, it was not possible to go further in the modelling of energy transition scenarios in line with the reduction objectives that we described in the preceding section.

Complete allocation of air pollutants to the sectors of activity was not carried out because the only pollutant exceeding the regulatory thresholds is nickel. As regards this pollutant, the metallurgical industry is responsible for 84%, whereas 14% are related to the rest of the industry.

Limitations of the linking exercise

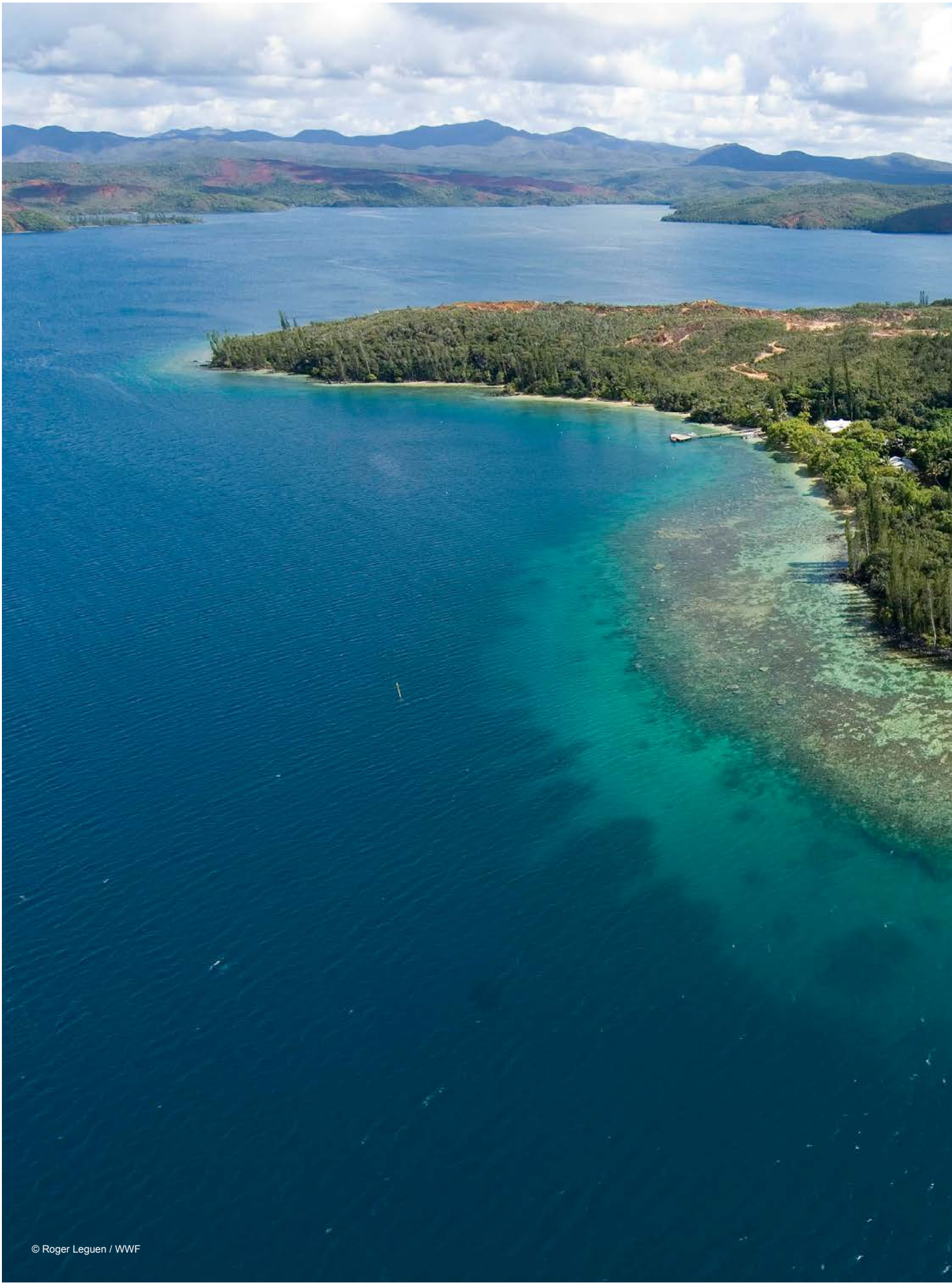
The main limitation encountered is related to the objectives of the New Caledonia strong sustainability economic diversification study, which were defined before being aware of the ESGAP study. Thus, the working time dedicated to creating the link with the ESGAP was (legitimately) limited. In addition, the environmental objectives chosen for the New Caledonia strong sustainability economic diversification study either come from existing public policies or workshops organized for the study (in order to be as close as possible to stakeholder action options) and not from scientific objectives. Indeed, the aim of this study was to create short and medium-term diversification scenarios and not to compare the situation in New Caledonia with scientific thresholds. We therefore recommend updating the scenarios and results of the New Caledonia strong sustainability economic diversification study with the strong sustainability objectives developed by the ESGAP. These objectives are operational in terms of public policy since they can be monitored over time using the indicators developed (see Section 3 and 4 of this report).

Another limitation of this work was the lack of data. Carrying out a complete and robust allocation of the uses of natural resources and degradation of the environment requires an *ad hoc* study for each environmental theme. In the case of New Caledonia, such a study only existed for GHG and air pollutants.

The only pollutant exceeding the regulatory thresholds is nickel. As regards this pollutant, the metallurgical industry is responsible for

84%

whereas 14% are related to the rest of the industry.



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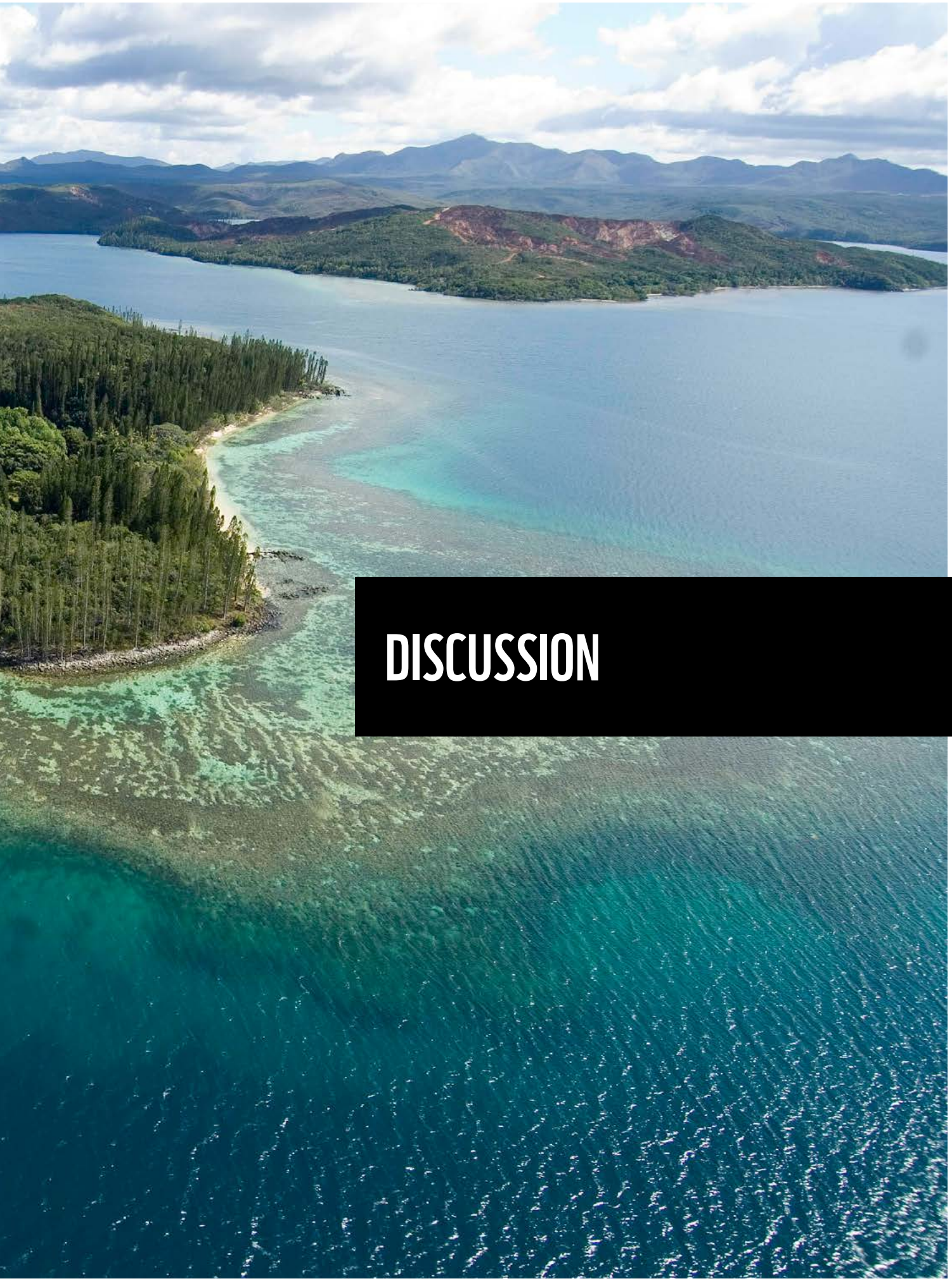

DISCUSSION

LESSONS LEARNT AND PROPOSALS FOR FUTURE ESGAP PROJECTS

The feasibility study for implementing SES and SESP indicators in New Caledonia enabled us to test several aspects of the ESGAP: (1) the concepts, (2) the indicators and associated objectives, (3) the availability of national and local data for its implementation and (4) the relationship between the decision makers and environmental managers with this decision support tool.

In this section, we will discuss two main themes related to these objectives: the possible revision of the ESGAP (its indicators, its objectives, and its conceptual framework) and the recommendations for implementing other pilot projects in various countries.

1 - REVISION OF THE ESGAP FOLLOWING THE PILOT PROJECT

THE CONCEPTUAL FRAMEWORK

Two important conceptual issues regarding the definition of the critical natural capital concern i) the degree of substitutability between the natural capital and the other forms of capital, and ii) the substitutability of the various forms of natural capital with one another. The New Caledonia ESGAP implementation experiment is faced with these two issues.

Definition of the critical natural capital outlines must be based on its non-substitutability with other forms of capital.

Definition of the critical natural capital outlines must be based on its non-substitutability with other forms of capital. Some authors suggest that the natural capital as a whole cannot be substitutable (Cohen et al., 2019). Critical natural capital divisions other than that proposed by the ESGAP functions are possible. For example, for Dietz and Neumayer (2007), only the life-support function is a non-substitutable natural capital, the other three being more or less substitutable with other forms of capital (human, productive, or social). According to several stakeholders consulted in New Caledonia, the fourth ESGAP function, "health and welfare", seems to be out of phase in relation to the first three. For these stakeholders, the first three functions are indeed critical functions of the environment, whereas the fourth seems to focus more on indicators that measure the provision of non-essential ecosystem services to the integrity of the biosphere. Therefore, there is a need to justify this function, which should be based on the criticality of the state of the environment on human health and welfare.

Another point that could be discussed is the option of placing at the same conceptual level, using common units and aggregating so-called "indoor-outdoor" and "outdoor-indoor" indicators (Richard, 2012). The first are indicators that concern the positive or negative impacts of the economy, or of humans, on the environment (the source and sink functions)

whereas the second indicators measure impacts of the environment on the economy (the health and welfare function, and notably evaluation of the water quality and state of conservation of UNESCO sites). The conceptual framework could therefore be clarified in order to know if we are interested in strictly environmental sustainability, or if other aspects are also included.

These two issues (boundary of the critical natural capital and weight relating to the various forms of natural capital) are found in the implementation of the SES composite indicator. If the fourth ESGAP function is disregarded, the SES score falls from 43% to 37%. The scope of the indicators and their weight is therefore extremely important in order to be able to answer the question "is New Caledonia sustainable?" This report does not seek to answer this question, but future work on these issues must take into consideration that the aim of the ESGAP is to be applicable to all countries so that they can be compared, and therefore that the scopes of the critical natural capital and the weighting of the dimensions that constitute it must be the same everywhere.

THE INDICATORS AND OBJECTIVES CONSTITUTING THE ESGAP

The indicators developed in the ESGAP are meant to extensively represent the critical natural capital, which corresponds to a state of the environment and can be approximated by pressure indicators if necessary. In our view, **three important issues for monitoring the integrity of the biosphere are not directly taken into account by the ESGAP indicators currently proposed.**

The first indicator that could be added is that of **the pressure exerted by fire on ecosystems**, in particular on forest ecosystems. Where these fires are caused by humans and are not natural, we were able to use a database on the fire surface in order to develop a critical load for ecosystems indicator. This is an important issue in many countries (United States, Australia, Brazil, Sub-Saharan Africa, etc.), as current events often remind us. Global information systems exist, which would enable this indicator to be calculated for all countries[10]. Nevertheless, a pressure indicator would affect the functionality of ecosystems over the long term and could therefore become a double count if included in the ESGAP. Moreover, the use of fire to manage areas is a practice that may also be virtuous (Whitehead et al., 2003).

A second indicator related to **the use of space is urbanization or soil sealing**. This indicator would be easy to calculate based on land use. In France, it is one of the new richness indicators. As for fire, this indicator makes no reference to a state of the environment but to a pressure that threatens the integrity of ecosystems, and that could become a double count given that the functionality of ecosystems is already represented by the BII.

A third indicator could be added to the human health and welfare section, on the **theme of emerging diseases**, which could help justify integrating this function into the ESGAP (see discussion). Damage to biodiversity and natural capital is one of the factors emerging from coronavirus, but also from many infectious diseases such as Ebola, SARS, etc. (WWF, 2020). Many animals are vectors of these diseases. This is notably the case of mosquitos (dengue, malaria, etc.). Works indicate that the transmission vectors are influenced by the state of the environment, with notably degradation of habitats and species richness, exploitation of animals, and an increase in the distribution zone of species at risk due to climate change. As the link between degradation of the environment and emergence of infectious disease is established, future work must focus on the development of one single and universal indicator that could be integrated into the ESGAP and into other global frameworks such as the SDGs (Di Marco et al., 2020). The development of an index for the emerging zoonotic infectious disease risk and its mapping on the global scale is an interesting area to be developed (Allen et al., 2017). The synergies and double-count risks with other ESGAP indicators such as the functionality of terrestrial ecosystems also need to be explored.

Three important issues for monitoring the integrity of the biosphere are not directly taken into account by the ESGAP indicators currently proposed.

INDICATOR CONSTRUCTION METHODOLOGY

Many methodological choices affect the final result of the SES composite indicator. These choices concern the number and type of indicators (pressure, state of the environment) used, and the construction of composite indicators (normalization of indicators).

[10] https://gfmc.online/

The initial version of the ESGAP aggregates pressure and state of the environment indicators, which poses a conceptual problem. Indeed, the variation of a pressure may result in a variation of the state of the environment. Thus, several indicators may be correlated, which would influence the weighting of the various themes covered by the ESGAP. The nature of the indicator, which provides information on a pressure or a state, will therefore influence the temporal sensitivity of the indicator. For example, forest clearing continues to have an impact by creating the edge for several decades (or even centuries), which contributes to forest fragmentation. Potentially, this means that the pressure indicators (critical load for ecosystems function) would react faster than the state indicators used for the biodiversity function. This raises the question of how often the ESGAP should be updated. The ESGAP may therefore theoretically be "green" whereas the dynamics go in the wrong direction, therefore these dynamics must be interpreted when communicating the results.

Three issues were identified regarding the construction of indicators. As regards the normalization of indicators, the arbitrary choice of a minimum value of 5 for the normalization of indicators could be reviewed. Indeed, we propose taking 1 as the minimum value. This value would be much easier to communicate for decision makers and managers and would assume the fact that all dimensions of the critical natural capital must be preserved. The choice of taking 5 resides in the SES composite indicator aggregation method, which is based on a geometric mean, the result being drawn by the lowest values. In our case, using 1 rather than 5 would have consequences on the value of the SES. The GHG indicator effectively has the lowest score, 5 in the normal case and 1 in the case proposed. This change would lower the overall score of the SES of 43%

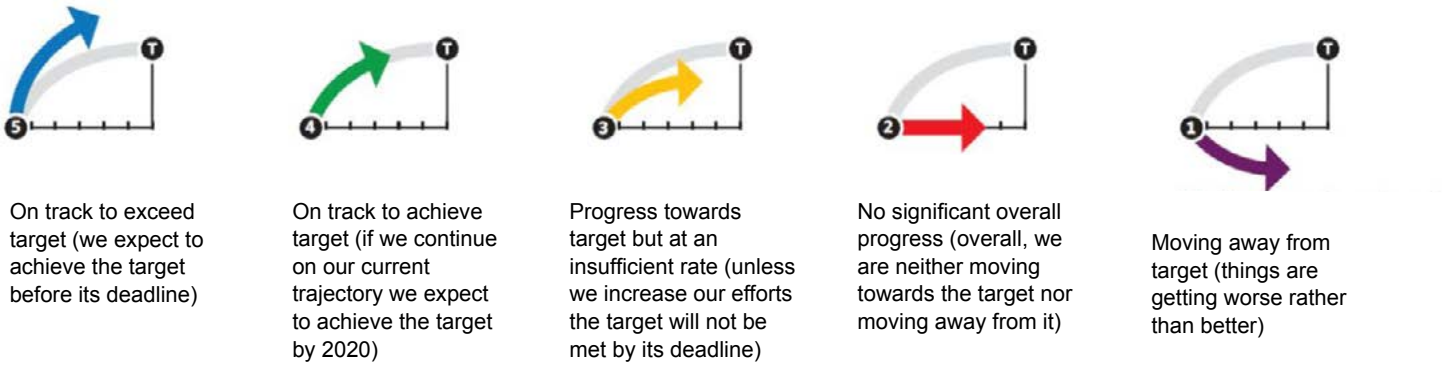

Figure 12. Pictograms used to monitor the Aichi targets. *Secretariat of the Convention on Biological Diversity, 2014.*

of sustainability to 35% of sustainability. With the state, this score cannot be compared with European countries for which the SES should be recalculated with a minimum score of 1.

The normalization of the SESP index also raises questions. As for the SES, the values are restructured from 5 to 100. This process makes it possible to standardize the indicators but results in a loss of information. Indeed, the gross value of the SESP supports 4 scenarios: if the evolution is negative, the indicator will go in the wrong direction, if it is zero, the indicator is not sustainable and does not vary over time, if it is positive but below 1, the indicator increases but not fast enough to be on a sustainable trajectory, if it is equal to 1, the indicator is on a sustainable trajectory. These various scenarios are also in the Aichi targets report, in the form of pictograms (Figure 12) (*Secretariat of the Convention on Biological Diversity*, 2014). It should be noted that a fifth scenario present in the Aichi targets report, exceedance of the objectives, is not applicable here. These pictograms are used here in Figure 5 to describe the SESP values of each indicator, rather than structure them from 5 to 100.

Before continuing use of the tool, statistical robustness tests should be carried out in order to check the quality of the indicators. For this, a guide exists produced by the Organisation for Economic Co-operation and Development and Joint Research Centre (OECD and JRC, 2008), training also being proposed.

LINKS WITH THE ESGAP GLOBAL DATASET

UCL produced a report on the use of global databases for completing the various ESGAP indicators (Fairbrass 2020). By analysing the databases listed, only two are used for New Caledonia: the BII for the functionality of terrestrial ecosystems and the state of conservation of UNESCO properties.

Two international information sources are not identified in the Fairbrass report. The indicator and the standard for forest resources, net non-loss of forest cover of natural areas, may not be suitable. For the sustainable exploitation of forest resources, we used a report that was produced locally but

that is intended for the FAO, and therefore must populate an international database. The publication of reports for the FAO of New Caledonia is more precise because it describes the planted surfaces and their evolution. So we used this figure as a basis for constructing the sustainable use of forest resources indicator. This indicator limits possible interpretations of the variation of its value and its evolution over time to a determined anthropogenic cause. The standard would be a stabilization of planted surfaces.

However, it explains nothing regarding the quality of forest exploitation (type of sampling, clearcutting, use of chemical inputs, etc.). Forest cover may also be lost without the cause being overexploitation of the resource. It may be due to urbanization, forest fire type disasters, etc.

Another international data source was identified. The European ESGAP uses the good state of water bodies as marine biodiversity indicator. These data originate from monitoring within the context of the Water Framework Directive and the Marine Environment Strategic Framework Directive. These directives only apply in Europe. Here, we use the good state of coral reefs as indicator. An international database, managed by the Global Coral Reef Monitoring Network (GCRMN) may therefore be a source of data for the marine biodiversity theme, in the intertropical zone (where the coral reefs are located).

Another international data source used is the state of fish stocks produced by the SPC (Brouwer et al., 2019). A large number of regional fishing committees exist, as well as an international body, the International Council for the Exploration of the Sea (ICES), that have data for measuring the sustainable exploitation of fish resources.

On the regional level, a project to make environmental data available could offer an interesting platform for future development of the ESGAP. This project, called INFORM, and set up by the Pacific Regional Environment Programme, is a portal for distributing data and improving environmental decision-making for the region. This portal would be an important gateway for new pilot projects in the Pacific region, on the regional or national scale. According to the developers of this data portal, New Caledonia is the territory with the best information system and the most data available on the ESGAP dimensions of the Pacific region (outside of Australia, New Zealand and the United States).

THE ESGAP IN THE PANORAMA OF BIOPHYSICAL INDICATORS

In our opinion, abandoning the "Years to Sustainability" indicator seems a shame because it represented interesting information about trajectories. The new SESP that replaces it is a good indicator because it follows the Eurostat methodology and corresponds to already known forms of reporting and accounting. In addition, it can be transposed into the CBD's achievement evaluations. On the other hand, we lose a dimension that is easy to communicate on the number of years needs to achieve the environmental objectives.

Other sustainability indicators propose a temporal vision that is easy to communicate. This is the case of the "overshoot day", based on the work on calculating the ecological footprint by the Global Footprint Network and used by WWF[11]. This methodology calculates the earth's capacity to produce renewable resources and absorb pollution related to human activities and aggregate them into bio-productive hectares necessary for achieving sustainability. It seems that **the ESGAP "Years to Sustainability" indicator has the potential to be just as easy to communicate and just as impacting as the "overshoot day", with a more operational aspect for the decision** since it not only describes whether or not sustainability is achieved, but also the achievement of strong sustainability objectives with regards to the efforts in progress.

The ESGAP *Years to Sustainability* indicator has the potential to be just as easy to communicate and just as impacting as the "overshoot day", with a more operational aspect for the decision.

Several conditions must be met to reintroduce "Years to Sustainability" in the panel of ESGAP composite indicators. Its calculation must be possible for a wide range of ESGAP dimensions, which for the moment is out of reach due to the absence of time series or to the trajectory resulting from those that exist. Indeed, "Years to Sustainability" cannot be calculated if the trajectory of a dimension moves away from strong sustainability[12]. An aggregation method must then be chosen to create the composite indicator: should the average number of years, or the highest number of years be chosen?

Given the evolution of the ESGAP, the current version with the SES and SESP seems to be very similar to what the "planetary boundaries" propose. The originality of the ESGAP was partly to do with its approach in terms of temporal distance to sustainability objective. In its current form, the temporal aspect becomes more technical and the SES

[11] https://www.wwf.fr/jour-du-depassement
[12] In this case, and if a collapse threshold exists for this dimension, a "Years to Collapse" could be envisaged

emerges as a variation of the planetary boundaries, as proposed by Rockstrom (2009) and Steffen (2015). Therefore, the added value of the ESGAP may be questioned in relation to the planetary boundary indicators. Noteworthy differences are the completeness of the ESGAP dimensions in relation to the planetary boundaries and its operationalization on several decision levels (local to global), when the planetary boundaries are difficult to define on scales other than the global scale.

2 - FEEDBACK FOR NEW PILOT PROJECTS

In this section, we formulate recommendations on the implementation of the ESGAP in other countries, based on feedback from its implementation in New Caledonia.

THE SELECTION OF DATA SOURCES

The meetings with local stakeholders are very important.

In order to adapt the structure, the environmental objectives and the indicators to the New Caledonia context, a decision tree was used (Figure 2). This decision tree made it possible to systematize the gathering of information on the local and international scales. Using this decision tree raises the question of whether to use global or local data sources (when both exist), given the objective of using and continuing the use of the ESGAP tool for environmental management in New Caledonia. Here, most international databases could not be used because New Caledonia is a territory and not strictly speaking a country. In the case were this problem would occur for the implementation of other ESGAP projects, a clear choice should be formulated, depending on whether the objective is international comparison or managing the environment locally.

This problem may also occur when selecting environmental objectives. Here, it was chosen to use an international standard when it was available, but adapting it to the specificities of New Caledonia (this is the case of soil erosion for example). The only indicator for which an international objective was used when a local objective exists is that regarding GHG emissions, because the local objective is very different from the ESGAP gold standard objective and does not permit comparison[13].

MEETING WITH LOCAL STAKEHOLDERS AND ENVIRONMENTAL DATA COLLECTION

A large number of stakeholders in NC are involved in the data collection and environmental management. Their geographical location enabled to meet them in an effective way. Indeed, most of these stakeholders are located in Nouméa. Only Province Nord and the CEN are located in Koné, in Province Nord. Although the other pilot sites are larger and more decentralized, a great deal of time may be needed to meet local stakeholders.

The meetings with local stakeholders are very important. The aim of these meetings is twofold. First, **to present the ESGAP study to the stakeholders** to provide a minimum of communication on this initiative and obtain interest and adhesion of the various stakeholders, in view of potential continuation of the tool locally. Second, **to discuss the relevance of the ESGAP's indicators and objectives in order to adapt them locally** if necessary and obtain data in order to complete the dashboard and the two synthetic indicators. Given this second technical objective, individual interviews were preferred over stakeholder group meetings.

We were able to hold meetings with most of the stakeholders contacted, with the exception of Province des Iles (cause unknown), and the SCRRE and the AFD which were preparing the Pacific Islands Conference on Nature Conservation and Protected Areas. The stakeholders had different reasons for receiving us, it is therefore important to identify the needs and responsibilities of the stakeholders to make it easier to get a meeting. For example, the SAP was interested in the integrated dimension and the link with the SDGs, themselves being in the process of collection environment information in view of producing a SDG reporting. Other stakeholders produce or use environmental indicators and were therefore interested in the ESGAP's framework.

The meetings did not enable us to obtain environmental data directly. The description of the ESGAP and the discussion on the indicators took too much time to actually obtain quantitative information directly. For this, it would have been necessary to carry out review work on existing data and read all

[13] In practice, using the local objective to reduce GHGs would result in the same ESGAP score given that emissions increase over the 2005-2016 period where data are available

of the reports produced for each stakeholder met, which was not possible given the large number of stakeholders and the short time for preparing the meetings (less than one month). It would certainly have been more effective to make specific requests regarding pre-identified data rather than requesting what is available in order to complete the ESGAP's indicators and objectives.

Carrying out cross-functional meetings with the team in charge of the New Caledonia strong sustainability economic diversification study (see Section 6) also shortened the time available for asking our questions during the meetings. These circumstances enabled us to have privileged access to an broad panel of environmental stakeholders, who would not necessarily have been as receptive in other circumstances. Carrying out face-to-face interviews also enabled us to explain the project and the process thereby making it easier to ask for access to the databases available.

These interviews therefore simply enabled us to make contact and prepare the competences, issues, and data available for each stakeholder. We then needed to make precise requests to obtain environmental data by email and by telephone. This process has not always been successful, so it is recommended to carry out interviews with specific requests related to the data available for each stakeholder.

Attention should also be paid to the stakeholders' responsibilities that are often at odds with the conceptual dimensions of the ESGAP. There were many scenarios. In New Caledonia, several stakeholders are responsible for collecting and managing data on behalf of other stakeholders (public or private), such as Oeil or BioEko, which is a bonus because these stakeholders generally have a holistic vision of the available data. However, this may be a problem because authorization from the stakeholders who own the data may be necessary.

Other stakeholders have competences that cover several ESGAP indicators, such as the DAVAR that is responsible for the water policy, and that therefore has information regarding all of the ESGAP dimensions relating to the aquatic environment, without in as much knowing how to conceptually split the available data. Some stakeholders also focus on a sub-section of an indicator (this sub-section may be geographical - e.g. in charge of data for only one Province - or categorical - in charge of collecting data for specific pollutants and not others such as Scal'Air). This configuration poses a problem because we need to be able to access the data of all of stakeholders for the same indicator and format them in order to construct the ESGAP indicator.

The variety of themes addressed in the ESGAP complicates the feasibility of having broad enough expertise for developing all of the indicators as well as the objectives. Therefore, the various dimensions of the ESGAP need to be discussed with the local decision makers and managers, who produce or use the indicators, in order to select the most suitable and the most robust data, proxies, indicators and objectives.

These discussions with the decision makers must also relate to the public policy strategies whether or not in place regarding the various ESGAP themes, in order to question the standards that can be used and the local priorities in terms of environmental policies.

2 AIMS

1 · To present the ESGAP study to the stakeholders.

2 · To discuss the relevance of the ESGAP's indicators and objectives in order to adapt them locally.

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