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## Article

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# 3

## An estimation of the Seychelles CO<sub>2</sub> footprint using Eurostat data

PATRICE GUILLOTREAU <sup>(1)</sup> AND KEVIN BISTOQUET <sup>(2)</sup>

**Abstract:** Small island developing states (SIDS) are particularly vulnerable to climate change and ought to pay attention to their own contribution in the form of carbon dioxide (CO<sub>2</sub>) emissions resulting from domestic production and consumption levels. Although barely responsible for worldwide carbon emissions by way of the modest level of their domestic demand, they can nonetheless contribute to the problem because of global demand for their exported commodities. However, the CO<sub>2</sub> footprint of SIDS is rarely assessed because of a lack of data about greenhouse gas emissions or national account statistics. Taking the opportunity of the COVID-19 pandemic and the resulting economic shock, an environmentally-extended input–output model based on Eurostat data on air emissions is used to disentangle CO<sub>2</sub> emissions embodied in domestic production and international trade, and to identify clearly the origin of emissions by industry. Not surprisingly, the consumption-based CO<sub>2</sub> footprint of Seychelles is deemed lower (6.79 tonnes of CO<sub>2</sub> per inhabitant) than the production-based inventory (9.55 tonnes of CO<sub>2</sub> per inhabitant) for this small open economy relying to a large extent on exports of canned tuna and tourism services. Hence CO<sub>2</sub> emissions decreased (–16 %) in 2020 because of the COVID-19 pandemic. Could it be the right time to re-frame the international specialisation of Seychelles?

**JEL codes:** D57, N57, Q25

**Keywords:** environmentally-extended input–output (EE-IO) model, air emission accounts, CO<sub>2</sub> footprint, COVID-19, Seychelles economy

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# 1. Introduction

It is well acknowledged that small island developing states (SIDS) are among the most vulnerable nations regarding global warming (Robinson et al. (2010), Guillotreau et al. (2012), Kelman (2018), Robinson (2020)). In particular, the issues of sea-level rising and climate variability for SIDS are under particular scrutiny since the United Nations (UN) Barbados Global Conference held in 1994 (<https://sdgs.un.org/>). Agricultural land, population and infrastructure are often concentrated in the coastal zones, making SIDS highly vulnerable to extreme climatic events. Although barely responsible for worldwide carbon emissions by way of the modest level of their domestic demand, they can nonetheless contribute to the problem because of global demand for their exported commodities. Assessing the carbon dioxide (CO<sub>2</sub>) emissions of SIDS would make it possible to identify the main sources of emissions and to implement targeted abatement policies ('charity begins at home'). The UN international Mauritius programme of action for the sustainable development of SIDS (2005) and the Bali Action Plan (2007) have first defined some nationally appropriate mitigation actions (NAMAs) to reduce the impact of SIDS and other developing countries on climate change through 'common but differentiated responsibilities and respective capabilities' (UNDP (2008)). The NAMAs aim at inventing pathways and specific steps for developing countries to reduce their emissions trajectory. Several conditions are required to follow the adopted action plans: the initiatives must be measurable, verifiable and reportable (*ibid.*). Developing such actions can be seen as a means of meeting sustainable development aspirations. It can also shed new light on particular industries which are vital, although overlooked for SIDS economies, such as natural resource-based industries and tourism (Burns and Vishan (2010), Pratt (2015)).

Depending to a great extent on foreign trade, the economic benefits of these activities for SIDS in terms of income can be outweighed by the negative environmental consequences of trade liberalisation (Sannasse and Seetanah (2016)). While developed countries tax more heavily polluting activities, the pollution haven hypothesis would tend to concentrate the most polluting industries in developing countries (Zheng and Shi (2017)). Separating production-based from consumption-based CO<sub>2</sub> emissions would show the respective responsibilities of developed trade partners and of small developing nations in global emissions (Nath and Madhoo (2021)). By reducing the weight of their most emission intensive activities, the SIDS economies can also become less dependent on fossil fuel energy, providing the double dividend of a 'no-regret' strategy, in other words a net gain even if the climate change does not result in too severe consequences (Hallegatte (2009)). They can do so by shifting to 'green' or 'blue' energy sources and deploying defensive strategies to enhance their environmental productivity (Nath and Madhoo (2021)).

Currently, the emission levels of CO<sub>2</sub> are calculated by both the International Energy Agency (IEA) and the Carbon Dioxide Information Analysis Center (CDIAC)<sup>(3)</sup>. However, there is no information regarding industry level breakdowns in the data, nor up-to-date input-output tables as developed in an environmentally-extended input-output (EE-IO) (Hertwich and Peters (2009), Wiedmann et al. (2011), Moran and Wood (2014), Wiebe and Yamano (2016), Wu et al. (2020), Brown et al. (2021)). Therefore, we propose in this research

<sup>(3)</sup> The CDIAC is a research centre of the United States Department of Energy calculating the CO<sub>2</sub> footprint through the multi-regional input-output model GTAP (global trade and analysis project). Their estimations can be found on the World Bank website (Hertwich and Peters 2009).

to develop an EE-IO model for the first time in Seychelles on the basis of Eurostat data on air emissions (Gajos and Prandecki (2016)), and to estimate both the CO<sub>2</sub> footprint and national inventory before and after the COVID-19 pandemic.

The concept of a CO<sub>2</sub> footprint is defined as a synthetic indicator of ecological sustainability (Boutaud and Gondran (2018)). The CO<sub>2</sub> footprint of a resident population represents the set of greenhouse gas (GHG) emissions, of which CO<sub>2</sub> is a major component, associated with domestic consumption, irrespective of the originating country where the goods and services are produced. The national inventory is a domestic production-based assessment, including the demand for exports but excluding the emission content of imports. Since the Kyoto Protocol signed in 1997 and the various Conferences of Parties afterwards, many countries have committed to reduce their emissions of CO<sub>2</sub>. Several studies have shown a transfer of emissions between developed countries and emerging or developing countries because of emissions embodied in international trade (Ahmad and Wyckoff (2003), Aichele and Felbermayr (2012), Wiebe and Yamano (2016), Wu et al. (2020)). As largely open economies, SIDS are particularly concerned by the gap between consumption-based and production-based emissions (Robinson (2020)). In particular, in many SIDS, the economic pillars are tourism and primary sectors (mining, agriculture and fishing), which may release a great deal of greenhouse gases into the atmosphere (Archer and Fletcher (1996), Chassot et al. (2021)). This is why it is of major importance to assess the Seychelles CO<sub>2</sub> footprint and inventory, attempting to disentangle the emissions embodied in trade and domestic production.

Such an assessment is a timely necessity as new challenges are arising for SIDS like Seychelles since the recent pandemic shock. On 11 March 2020, the World Health Organization (WHO) declared COVID-19 a worldwide pandemic resulting in a wave of lockdowns for many countries. The International Monetary Fund (IMF) considered that global GDP for 2020 would be reduced by 3.5 % in their revised estimation of January 2021, before bouncing back to growth of 5.5 % in 2021 and 4.2 % in 2022 according to projections (IMF (2021)). The African Bank of Development (AfdB), in its outlook of March 2021, predicted the lowest rate of change (–12 % in 2020) of all East-African countries (AfDB (2021)). The World Trade Organization (WTO) predicted that global trade would contract between 13 and 32 % in 2020 (WTO (2020)). On the basis of autoregressive models and impulse response functions, the UN Department of Economic and Social Affairs predicted a situation for SIDS that should be even worse than the financial crisis of 2008–2009, since the length of recovery depends on the magnitude of the initial shock: SIDS are projected to take about four years to return to the baseline forecast path (Kim (2020)). Consequently, the level of CO<sub>2</sub> emissions associated with production and consumption should be somehow affected by the trade restrictions imposed by the pandemic.

SIDS rely heavily on foreign trade and supply of commodities for day-to-day life. In particular, the energy required by the Seychellois households and industries is fossil fuel-based. Machinery and transport equipment represent 30 % of imports. Even the fish canning plant, the main private employer of the archipelago, needs a large quantity of raw materials like frozen tuna and tin metal cans from overseas. A sudden disruption of foreign trade affects dramatically the whole economy (Kontovas and Sooprayen (2020)). In Seychelles, a comprehensive report assessing the economic consequences of the COVID-19 pandemic for the country was published by the government and the United Nations in December 2020 (Rassool et al. (2020)). It clearly showed the extent of the social and economic shock caused by

the pandemic, with a gross domestic production (GDP) contraction of 11.5 % in 2020 (the IMF's 2020 forecast was even higher at –13.8 % for 2020). The budget balance relative to GDP was one of the lowest among SIDS at –15.5 % in 2020, with a projection of –6 % in 2021 (Rassool et al. (2020)). Exports decreased by 38.9 % in 2020 (IMF (2021)), and the actual GDP contraction in 2020 estimated by the National Bureau of Statistics finally amounted to –11 % relative to the previous year (NBS (2021)).

The COVID-19 pandemic deeply affected the whole economy but some industries suffered more than others, like the tourism sector which experienced a 70 % reduction in its number of visitors in 2020. Tourism is considered as the main pillar of the economy in Seychelles and would normally represent one quarter of the Seychelles GDP directly, and two thirds after including indirect and induced effects (Archer and Fletcher (1996), Valenghi (2004), Pratt (2015)). The second most important source of income comes from the fishing and tuna processing industries, contributing 10 % to 15 % of the GDP directly and indirectly (Rassool et al. (2020)). A new prevailing role was assigned to fishery-related industries and the 'blue economy' after the COVID-19 shock. In recent years, Seychelles has developed an ambitious and innovative programme for the development of the blue economy (Republic of Seychelles (2018)). The blue economy is hard to define and delineate accurately, though it follows the overarching objective of UN-SDG 14 ('conserve and sustainably use the oceans, seas and marine resources for sustainable development'). However, these two industries (tourism and fishing) are both highly energy-dependent, and hence responsible for a great deal of CO<sub>2</sub> emissions in Seychelles. How is the new deal of economic activity after the pandemic changing the rules and re-allocating carbon emissions between industries? Will the economy come back to the current specialisation after the shock, or take this opportunity to re-direct its resources to a 'greener' (or 'bluer') economy? A thorough analysis of carbon emissions resulting from domestically-produced and imported commodities might help the government to decide what the best options are for the country.

This article starts in Section 2 with a first glance at Seychelles CO<sub>2</sub> emissions as reported by some international agencies. An original EE-IO model is introduced in Section 3, following the international methodological standards used by the EU Member States and other OECD countries to allow for comparisons. A numerical application, including the estimated impact of the COVID-19 pandemic on carbon emissions, is proposed in Section 4 on the basis of a supply-use table recently released by the National Bureau of Statistics for the first time. Finally, the last section discusses the results in terms of international specialisation for Seychelles.

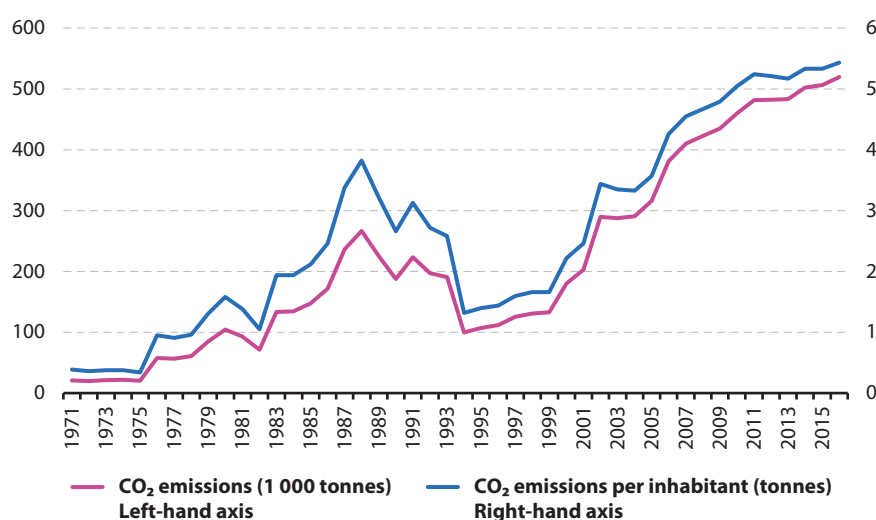
## 2. Overall CO<sub>2</sub> emissions in Seychelles

Data about emissions from fuel combustion are made available, among others, by the International Energy Agency (IEA) ([www.iea.org](http://www.iea.org)). CO<sub>2</sub> emissions are calculated using IEA energy databases and the default methods and emission factors given in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories <sup>(4)</sup>. From IPCC sources, we learn that CO<sub>2</sub> emission factors for electricity and heat have been derived as 'the ratio of CO<sub>2</sub> emissions from fuel inputs of power plants relative to the electricity and heat delivered' ([www.ipcc.ch](http://www.ipcc.ch)). The

<sup>(4)</sup> See <https://www.worldometers.info/co2-emissions/seychelles-co2-emissions/>.

calculation is conducted at the country level, indirect emissions being derived by multiplying the amount of energy and heat consumed by CO<sub>2</sub> emission factors at the sectoral level. The Emission Database for Global Atmospheric Research (EDGAR) developed by both the European Commission Joint Research Centre (JRC) and the Dutch environmental assessment agency provides an independent database of atmospheric emissions for all countries in the world since 1970. The calculation of emissions uses a technology-based emission factor approach combining data from the IEA, the Food and Agricultural Organization (FAO) and additional sources (Crippa et al. (2021)) <sup>(5)</sup>. The results for Seychelles are presented in the figure below (Figure 1).

**Figure 1: CO<sub>2</sub> emissions from fuel combustion, Seychelles, 1971–2016**



Source: own calculations from IEA and EDGAR data released by [www.worldometers.info](http://www.worldometers.info)

The amount of emissions can vary between sources, for instance between the IEA and the World Bank indicators based on data issued by the Carbon Dioxide Information Analysis Center (CDIAC). The IEA appears to be the most cited reference when dealing with CO<sub>2</sub> emissions from heat and energy. The level of air emissions in Seychelles has grown tremendously since the early 1970s, from 20 000 tonnes annually to more than 500 000 tonnes in 2016 (Figure 1). A large proportion (82 %) of these emissions is released by the power industry itself, based on fossil fuels, and the remaining part by other process of combustion, including transport and in buildings. The increasing trend is obviously explained by the growing population but also by the economic development of the country, as illustrated by the steadily increasing level of emissions per inhabitant, from less than half a tonne to more than 5.4 tonnes over the same period of time. We can compare this last figure to the average worldwide carbon emissions of 1.35 tonnes per inhabitant in 2014, meaning that Seychelles is well above average and very close to the EU level of 5.7 tonnes according to Eurostat <sup>(6)</sup>.

<sup>(5)</sup> Emission Database for Global Atmospheric Research EDGARv6.0\_GHG websites: [https://edgar.jrc.ec.europa.eu/dataset\\_ghg60](https://edgar.jrc.ec.europa.eu/dataset_ghg60); [https://data.europa.eu/doi/10.2904/JRC\\_DATASET\\_EDGAR](https://data.europa.eu/doi/10.2904/JRC_DATASET_EDGAR); more information about the methodology can be found in Crippa et al. (2021).

<sup>(6)</sup> See the Eurostat portal <https://ec.europa.eu/eurostat/>, including air emissions accounts (AEA) by NACE Rev. 2 activity.

However, the above figures do not tell anything about the import content of emissions relative to domestic production, nor the details by industry. This is why we suggest to use the standard input–output approach extended to environment proposed by Leontief in 1970 and introduced in greater details in Suh (2009) or Miller and Blair (2009). In Chapter 10, Miller and Blair (2009) explain how to extend the famous Leontief model to deal with energy flows or any environmental factor measured in monetary or physical terms. It can be done in a single-country or multi-regional framework, with respect to the level of available information about emissions, inter-industry transactions and international trade (Hertwich and Peters (2009), Moran and Wood (2014), Wiebe and Yamano (2016), Wu et al. (2020)). A good starting point for Seychelles would consist in developing a single environmentally-extended input–output (EE-IO) model taking into consideration the import content of emissions. This would further serve for other types of footprint (water, energy, raw materials and waste) that could be helpful to minimise the impact of the economy on the natural environment.

### 3. The environmentally-extended input–output approach

In an environmentally-extended input–output model (EE-IO), the indirect emissions resulting from inter-industry linkages along supply chains are considered in addition to the direct emissions produced by each industry and by end users (households, government, investors and the rest of the world). A symmetric input–output table is therefore needed to calculate the input coefficients and the multipliers. Starting from the classical Leontief model:

$$X = (I - A)^{-1} \cdot F \quad (1)$$

where  $X$  is a column vector of output,  $A$  is the matrix of technical (or input) coefficients (the industry's requirements in every input to produce one unit of output in monetary terms),  $I$  is the identity matrix and  $F$  is a column vector of final uses (internal and external, see below).

The impact factors need to be expressed as intensity rates in physical terms (for example, gigagrams of CO<sub>2</sub>) per monetary unit of output  $e_j = E_j / X_j$ , where  $E_j$  denotes the industry  $j$ 's CO<sub>2</sub> emissions and  $e_j$  the intensity (or direct impact) coefficient, in other words the amount of pollutant type per unit of industry  $j$ 's output value. The industry  $j$ 's CO<sub>2</sub> emissions are therefore  $E_j = e_j \cdot X_j$ . Now substituting  $X$  by its value in (1) gives the level of emissions directly and indirectly resulting from industry  $j$ 's activity:

$$E = e_j \cdot (I - A)^{-1} \cdot F \quad (2)$$

The interpretation is easy: any change by one unit of final demand for commodity  $j$  will result in a  $e_j \cdot (I - A)^{-1}$  shift of direct (the industry and its first suppliers) and indirect emissions (the

suppliers' suppliers in a chain of cascading effects). What matters then is to separate the emissions caused by domestic production from those linked with imported inputs used by industries and those associated with imports of final goods and services. To do so, we followed the stepwise methodology to calculate the CO<sub>2</sub> footprint in France and in the rest of

Europe or OECD countries (Pasquier (2018), Wiebe and Yamano (2016), Brown et al. (2021)). Firstly we try to measure domestic production-based emissions:

$$E_j^d = \widehat{e}_j^d \cdot (I - A^d)^{-1} \cdot \widehat{F}^d \quad (3)$$

The capital letters denote the column-vectors, the hat symbol stands for an operator transforming a column-vector into a diagonal square matrix, the superscript  $d$  means domestic.

The import vector of the country must be split into the matrix of imported inputs ( $A^m$ ) used

by the domestic industries and the vector of imported commodities and services for final uses ( $F^m$ ):

$$M = A^m X + F^m \quad (4)$$

Substituting  $X$  by its value in (1), we obtain:

$$M = A^m \cdot (I - A^d)^{-1} \cdot F^d + F^m \quad (5)$$

The CO<sub>2</sub> emissions embodied in imports from a country  $c$  will depend both on the share this exporting country holds in the domestic imports, on its own emission intensity coefficients by industry, but also on the technology (combination of inputs) used to produce a commodity. For instance, producing electricity through renewable energy or fossil-based inputs will not result in the same level of CO<sub>2</sub> emissions. Consequently, the emissions embodied in imports can be written as:

$$E^{m,c} = \widehat{e}^c \cdot (I - A^c)^{-1} \cdot \widehat{M} \quad (6)$$

We can replace  $\widehat{M}$  in Eq. (6) by its value in (5):

$$E^{m,c} = \widehat{e}^c \cdot (I - A^c)^{-1} \cdot \left[ A^m \cdot (I - A^d)^{-1} \cdot \widehat{F}^d + \widehat{F}^m \right] \quad (7)$$

By doing so, we can isolate the emissions embodied in imports of intermediate inputs by domestic industries  $E_{ic}^{m,c} = \widehat{e}^c \cdot (I - A^c)^{-1} \cdot \left[ A^m \cdot (I - A^d)^{-1} \cdot \widehat{F}^d \right]$ , and the emissions embodied in

imports of commodities for final uses,  $E_f^{m,c} = \widehat{e}^c \cdot (I - A^c)^{-1} \cdot \widehat{F}^m$

By assuming a certain stability of input coefficients throughout time, both for domestic or imported input requirements of industries, we can estimate the current level of CO<sub>2</sub> emissions for the year of reference, but also calculate the percentage change of emissions after an economic shock like the COVID-19 pandemic, by substituting  $(\widehat{\Delta F}^d + \widehat{\Delta F}^m)$  for  $(\widehat{F}^d + \widehat{F}^m)$ .

Eq. (7) represents the footprint which is consumption-based, in other words including the domestic demand in  $\widehat{F}^d$  but excluding the foreign demand (exports) of domestically-



produced goods and services. It can be distinguished from a national inventory of production-based emissions, where the column-vector of exports will be re-integrated into  $\hat{F}^d$  but where also  $\hat{F}^m$  will not be considered in Eq. (7).

One further objective to improve the estimation is to use a multi-regional input-output (MRIO) model (Hertwich and Peters (2010)). Although foreign trade data in Seychelles are poorly detailed by commodity, origin and destination, it remains possible to use a simple MRIO model such as the one introduced by Miller and Blair (2009, pp. 264), where two countries would be considered (for example, Seychelles and EU):

$$E = \hat{e} \cdot (I - CA)^{-1} \cdot CF \quad (8)$$

where E represents the vector of emissions resulting from the final demand, irrespective of where the goods are produced,  $\hat{e}$  denotes a diagonal vector of emission intensity per unit of

output in the domestic and trade partner countries, the two matrices A and C are, respectively:

$$A = \begin{bmatrix} A^r & 0 \\ 0 & A^s \end{bmatrix} \quad C = \begin{bmatrix} \hat{c}^{rr} & \hat{c}^{rs} \\ \hat{c}^{sr} & \hat{c}^{ss} \end{bmatrix} \quad (9)$$

A is a block diagonal matrix whose submatrices represent regional technology structures (technical coefficient matrices). Matrix C represents trade flows within and between regions as a proportion (in other words, market share) of total trade for every commodity, including the domestic region which is considered (in other words, the sum in column is equal to 1). Finally, F is the demand for exogenous sectors in the domestic country and trade partners. The multipliers obtained by  $\left[ \hat{e} \cdot (I - CA)^{-1} \cdot C \right]$  would give not only the direct and indirect emissions due to a level or a change of exogenous final demand in the country, but would distribute the emission effects across supplying regions according to the percentages embodied in the components of block matrix C (Blair and Miller (2009)).

## 4. Application to the Seychelles case

### 4.1. Data

The application of the EE-IO model requires different types of data: input-output techniques, CO<sub>2</sub> emissions by industry, final uses and so on. Not all data are available yet for Seychelles. However, in 2020 the National Bureau of Statistics (NBS) published a supply and use table for the year 2014 for the first time, with a selection of 23 key industries for the domestic economy (NBS (2021)). On that basis, an input-output table was constructed but with no distinction between domestic and imported inputs. Consequently, we had to estimate first the import (inter-industry) matrix ( $A^m$ ) by allocating the vector of imports *M* proportionately to the distribution of intermediate and final output (see Miller and Blair (2009), pp. 151, for an explanation of the method). The domestic IOT is shown in the Appendix (Table A1).

From that point, we were in a position to calculate both  $A^d$  and  $A^m$  matrices, the sum of which represents the total technical coefficient matrix ( $A = A^d + A^m$ ). The  $A$ -matrix was used as a proxy of the foreign country technology structure, assuming that both national and foreign technologies were identical. This is not unrealistic because the biggest domestic industries in Seychelles (such as the fish cannery, Indian Ocean Ltd) are foreign capital-owned, compete internationally and export most of their output to EU Member States (Germany, France, Italy, and so on), hence having the highest technology standards to produce and export commodities.

When it comes to emission intensity coefficients, we used the EU CO<sub>2</sub> emissions, adjusted for African countries<sup>(7)</sup>. The IEA suggests to apply coefficients of deviation to the EU (air emission accounts) database at Eurostat of air pollutant emissions, with a different coefficient for electricity and non-electricity industries (Pasquier et al. (2018)). The emission coefficients  $e_j$  are expressed in 1 000 tonnes of CO<sub>2</sub> per EUR million, and thus need to be converted by the exchange rate in 1 000 tonnes per SCR million (the Central Bank rate was SCR 16.96 per euro in 2014). The coefficients were then averaged for some industries to be adjusted from a 65-row vector to a 23-row vector. Note that a single CO<sub>2</sub> emission coefficient of the manufacture of food, fishery, beverage and tobacco products from the EU classification in 65 industries was used for the three distinct industrial categories found in the Seychelles industrial classification. The table of emission coefficients according to the Seychelles industry classification (SIC), corresponding to a selection drawn from the ISIC (UN international standard industrial classification of all economic activities), is shown in the Appendix (Table A2).

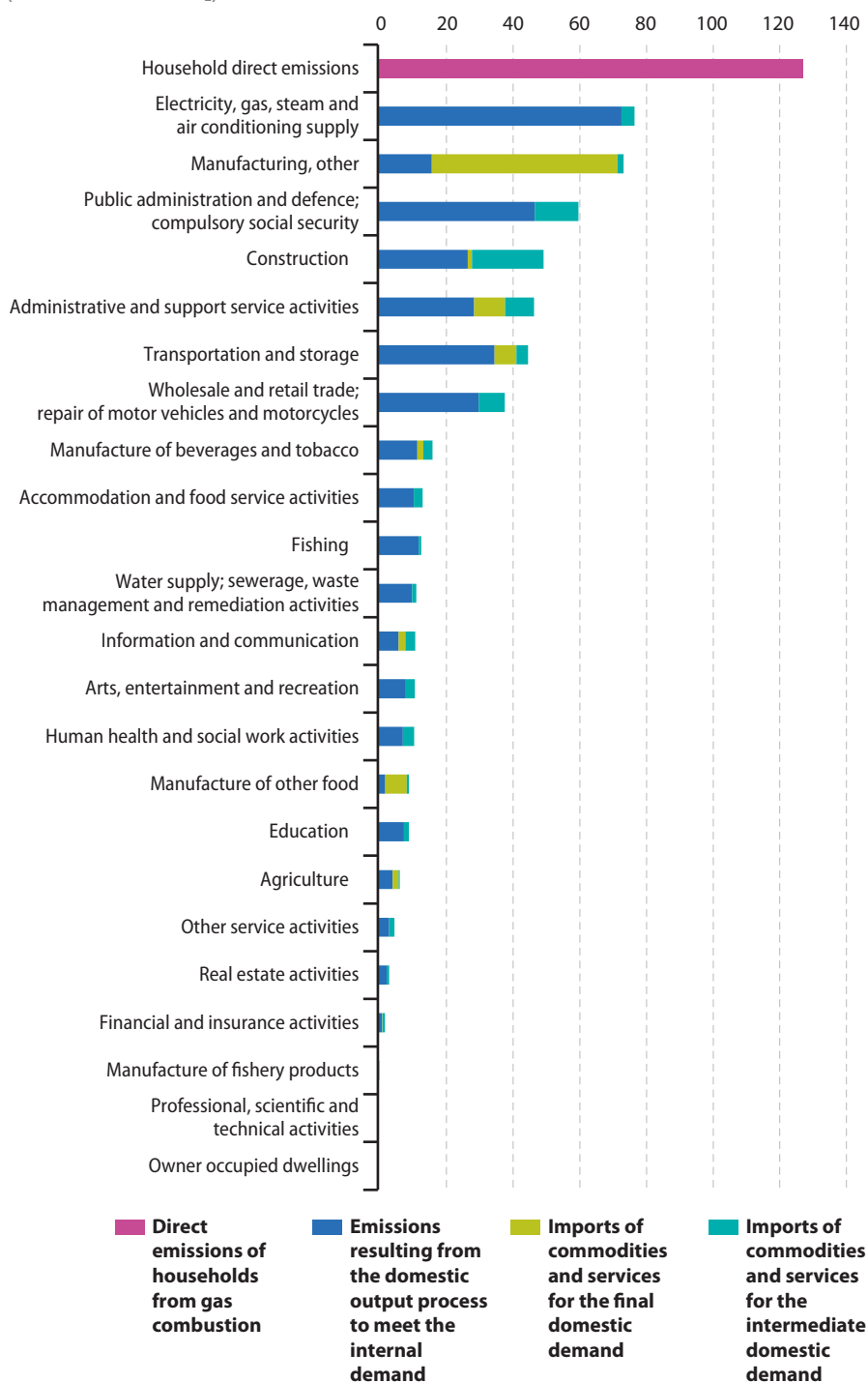
The last missing information concerned the direct emissions released by domestic households: CO<sub>2</sub> emissions resulting from the use of personal vehicles, air-conditioning, cookers and other devices. They are available for the EU Member States, such as France (1.76 tonnes of CO<sub>2</sub>-equivalent per inhabitant in 2014) or the whole EU (1.59 tonnes of CO<sub>2</sub>-equivalent per inhabitant in 2014). At the worldwide level, the CDIAC provides a figure of 1.35 tonnes of CO<sub>2</sub>-equivalent per inhabitant, which may be used as a proxy value for the country (Boden et al. (2017)).

## 4.2. Results

Beyond the direct emissions of households from combustion (personal vehicles and other equipment) representing 127 000 tonnes, the indirect emission content of final demand resulting from domestic production was calculated with equation (3). The CO<sub>2</sub> footprint of Seychelles (direct + indirect emissions) reached 640 000 tonnes of CO<sub>2</sub> in 2014, in other words 3.67 tonnes per inhabitant. Such a figure may look quite high if we consider that imports represent 25 % of final domestic consumption, but local industry relies mostly on fossil fuel energy which is highly CO<sub>2</sub>-emitting.

<sup>(7)</sup> Available from the Eurostat website: <https://ec.europa.eu/eurostat/>, file of air emission accounts for 65 industries + direct emissions [env\_ac\_ainah\_r2]. The coefficient for Africa in 2014 was 2.47 for non-electrical industries, and 2.00 for the electricity industry.

**Figure 2: CO<sub>2</sub> emissions resulting from domestic demand by industry and direct combustion, 2014**  
(1 000 tonnes of CO<sub>2</sub>)

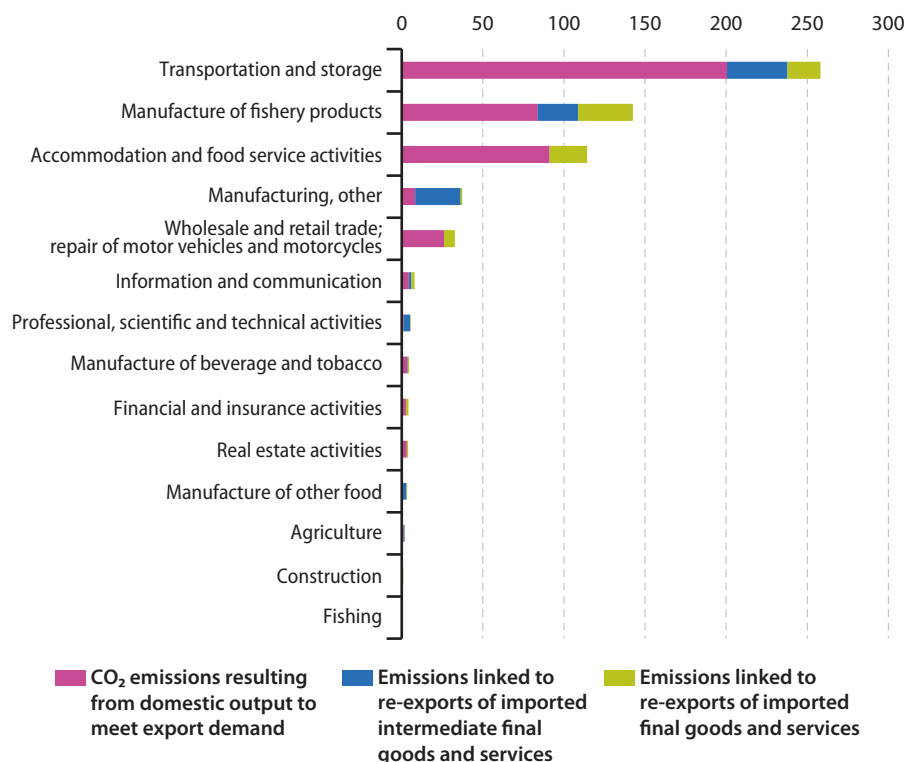


Source: own calculations

We can identify the key industries responsible for the highest level of CO<sub>2</sub> emissions with regard to domestic or foreign origin (Figure 2). As far as the domestic GHG emissions resulting just from domestic demand (households' consumption + enterprises' investment + government expenditure) are concerned, domestic output generates two thirds of the CO<sub>2</sub> footprint, and another third is from imports of intermediate and final commodities. A large proportion of territorial emissions (21 %) originate from the electricity and gas sector because of the fossil fuel origin of energy, but the public administration and defence industry is the second largest (14 %), followed by transportation and storage, wholesale and retail, administrative and support services, and construction with very close shares (10 %, 9 %, 8 % and 8 %, respectively).

The picture is rather different when looking at the import content of emissions associated with domestic demand (Figure 2). First, the 'other manufacturing' industry produces two thirds of the emissions from imports of final goods (cars, electric and electronic equipment, and so on), the remaining share resulting mostly from three industries (administrative and support services, transportation and storage, and the manufacture of other food products). As far as the emissions from imported inputs (intermediate consumption) are concerned, CO<sub>2</sub> emissions stem from a broader variety of industries (construction, public administration and defence, administrative and support services, wholesale and retail trade, and so on).

**Figure 3: Analysis by industry of CO<sub>2</sub> emissions resulting from exports, Seychelles**  
(1 000 tonnes of CO<sub>2</sub>)



Source: own calculations

In the national inventory, only the emissions issued by the domestic output to meet the foreign demand for exports is included, for a total amount of 427 000 tonnes. However, exported commodities such as canned fish also need imports (for example, frozen fish) whose production process is CO<sub>2</sub>-emitting. When adding the emissions embodied in imports for external demand served by the Seychellois industries, the cumulative amount of emissions would reach 617 000 tonnes. Three industries are particularly involved in CO<sub>2</sub> emissions for exports, reflecting the economic specialisation of the country. Transportation and storage is the first one, in particular to meet the external demand for tourism services. The second pillar of the economy, namely the manufacture of fishery products, comes in second position, and finally, accommodation and food services (still for tourism purposes) is the third most polluting industry.

In order to summarise the previous values, the total CO<sub>2</sub> footprint of Seychelles is displayed in Table 1.

**Table 1: CO<sub>2</sub> footprint, Seychelles, 2014**

	<b>Total emissions (1 000 tonnes of CO<sub>2</sub>)</b>	<b>Emissions per inhabitant (tonnes of CO<sub>2</sub>)</b>
<b>Direct emissions of households <sup>(1)</sup></b>	127	1.35
<b>Emissions resulting from domestic output</b>	346	3.67
<b>Emissions embodied in imports for final use</b>	85	0.90
<b>Emissions embodied in imports for intermediate use</b>	82	0.87
<b>TOTAL CO<sub>2</sub> footprint (excluding exports)</b>	<b>640</b>	<b>6.79</b>

<sup>(1)</sup> The direct emissions per inhabitant were extrapolated from Boden et al. (2017). The size of the Seychelles population was 94 215 inhabitants in 2014 (NBS 2021).

This first assessment of a detailed CO<sub>2</sub> footprint for Seychelles is consumption-based, in other words not looking at the origin of commodities that are domestically consumed. This means that emissions related to exports are excluded. Re-assessing national emissions on the simple basis of domestic production, whether the output is consumed internally or in foreign countries, would give a totally different picture. When subtracting imported emissions for final use and including the CO<sub>2</sub> content of exports, total CO<sub>2</sub> emissions related to domestic production (in other words, the national inventory) would reach 900 000 tonnes (or 9.55 tonnes of CO<sub>2</sub> per inhabitant), far above the CO<sub>2</sub> footprint in Table 1.

It should also be noted that the total CO<sub>2</sub> footprint per inhabitant is estimated at 6.79 tonnes but this figure encompasses direct household emissions linked with energy consumption through personal vehicles, air conditioning and other devices estimated by total emissions per inhabitant at the worldwide level (Table 1). This latter amount may therefore include also industrial emissions and be counted twice. When excluding households' direct emissions, the footprint falls to 5.44 tonnes of CO<sub>2</sub>, a level which is quite close to the one estimated by the IEA, 5.33 tonnes of CO<sub>2</sub> (worldometers.info). We try to figure out why the total footprint in Table 1 is perhaps over-estimated through a sensitivity analysis (Subsection 4.3 below).

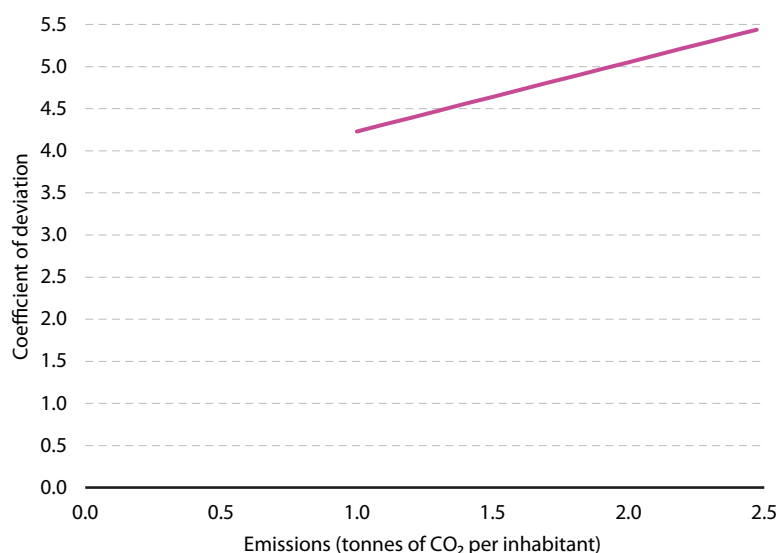
We can first compare these results with a different approach based on a MRIO model (equation 8 and equation 9 in the previous section). Because NBS does not provide any details about foreign trade combining commodities and origin or destination, it was not possible to distribute the regional effects between partner countries. We chose to integrate the trade between Seychelles and the EU for which we know the A-matrix of technical coefficients and the e-vector of emission intensity by sector. We therefore assumed that all Seychelles imports originate from the EU and that all Seychelles exports are directed to EU partners.

Such an assumption remains fairly realistic because EU Member States supplied 34.4 % of Seychelles imports and absorbed 88 % of Seychelles exports in 2020 for goods. The other major suppliers from which Seychelles imports goods are the United Arab Emirates (26.5 % in 2020), South Africa (6.5 %), India (5 %), China and Mauritius (3.5 % each) (NBS (2021)). EU visitors also represented 57 % of foreign tourism visits between January 2010 and March 2020 (source: Central Bank of Seychelles). In our estimation, just the domestic demand (excluding exports) was retained as the exogenous final demand vector. The results obtained are slightly lower than the results of Table 1: domestic CO<sub>2</sub> emissions resulting directly or indirectly from domestic output amounted to 307 000 tonnes (in other words, 3.26 tonnes per inhabitant). The emissions in other countries proxied by the EU and resulting from the Seychelles final demand reached 187 000 tonnes (or 1.98 tonnes per inhabitant), in other words 494 000 tonnes overall (5.24 tonnes per inhabitant), not including direct emissions by local households. Consequently, this other way of assessing CO<sub>2</sub> emissions gave reasonable results, only 4 % lower than the previous EE-IO model, though difficult to interpret at the industry-specific level.

### 4.3. Sensitivity analysis

The previous estimations of CO<sub>2</sub> emissions, resulting from the domestic production for internal final uses, or from CO<sub>2</sub> embodied in imported commodities for final or intermediate domestic uses, were based on EU intensity coefficients adjusted for Africa by the IEA coefficients of deviation (CD). We assume now that the technology used by Seychelles to produce goods and services is exactly identical to the EU technology, hence emission coefficients by industry equivalent to the EU ones in the Appendix (Table A2). The sensitivity of the CO<sub>2</sub> per inhabitant outcome as a function of the CD varying from 1 (equivalent to EU technology) and 2.47 (or 2.00 for the electricity and gas sector) is shown in Figure 4.

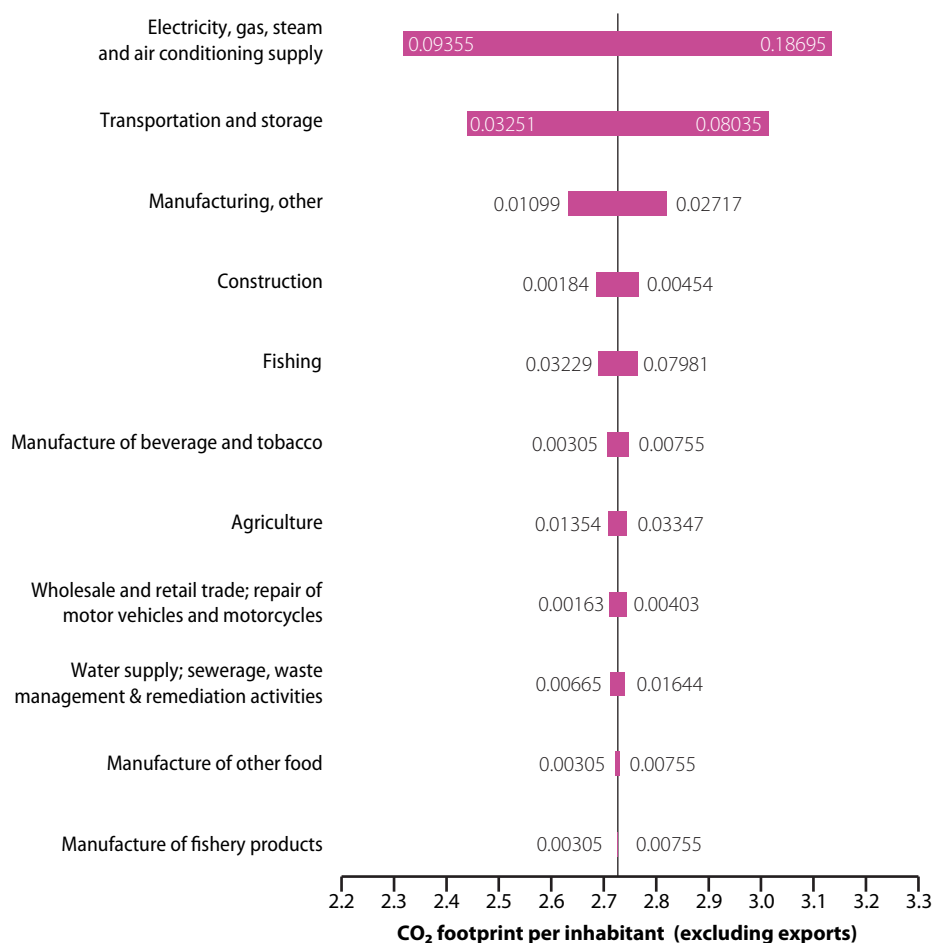
**Figure 4:** Sensitivity to the coefficient of deviation – CO<sub>2</sub> emissions per inhabitant, Seychelles



Source: own calculations with R software (R Core Team, 2021)

A perfect match between the EU and Seychelles emission coefficients ( $CD = 1$ ) would result in 4.23 tonnes of CO<sub>2</sub> per inhabitant (emissions embodied in [domestic output + imports for final demand + imports for intermediate demand]). Adding this amount to the households' direct emissions of Table 1 would then give a total amount of 5.58 tonnes of CO<sub>2</sub>, more in line with the overall IEA estimation of 5.33 tonnes of CO<sub>2</sub> in 2014. We now estimate the influence of the CD, industry by industry (Figure 5).

**Figure 5: Sensitivity of CO<sub>2</sub> emissions per inhabitant to the coefficient of deviation analysed by industry, Seychelles, 2014**



Source: own calculations with SensIt 1.53 software

In Figure 5, the individual effect of each industry is calculated by using values of the emissions coefficient (CO<sub>2</sub> per unit of output) between the EU (CD = 1) and Africa-adjusted emission coefficients (EU rates multiplied by a CD = 2.47 for non-electrical industries or 2.00 for the electricity and gas industry) centred on the mean between the lowest and highest values of the intensity ratio by industry. For instance, the electricity and gas CO<sub>2</sub> coefficient fluctuates between 0.094 and 0.187 with a mean value of 0.140. Consequently, the footprint per inhabitant would be between 2.32 and 3.14 tonnes of CO<sub>2</sub>, other things being equal (in other words, other ratios remaining in their mid-value). Obviously, the energy sector has the most prominent effect on the CO<sub>2</sub> footprint, followed by the 'transportation and storage' and 'other manufacturing' industries to a lesser extent. The remaining industries have a much smaller influence on domestic emissions per inhabitant. The impact of each industry is not only explained by the intensity of emissions per unit of output value, but also by the level of final demand for the various commodities and the technology of the country in terms of inputs to produce one unit of output (Leontief matrix). In addition to the intensive use of fossil fuel-based energy, the transport and energy sectors cumulate a high level of demand from all industries and institutional end users, with strong backward and forward linkages across the economy. As a result, the footprint level is unsurprisingly linked with these two industries.

#### 4.4. Impact of the COVID-19 pandemic

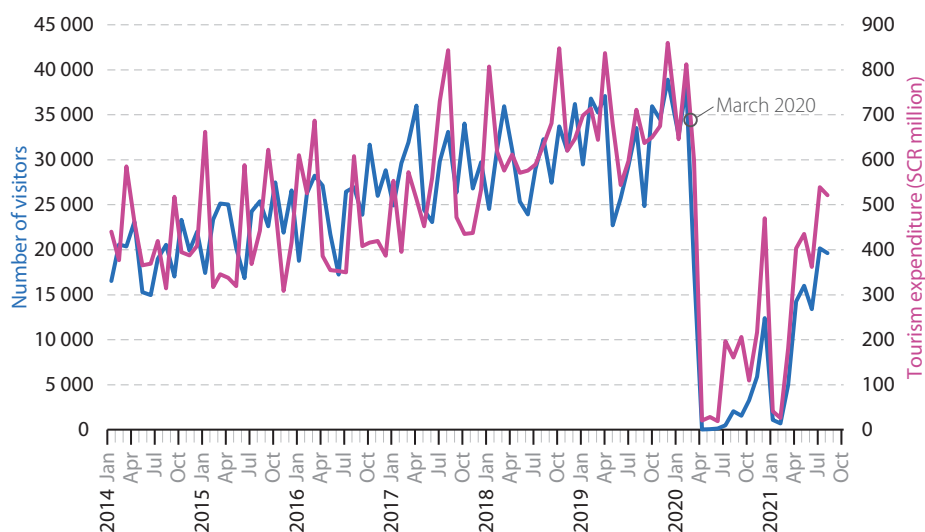
Like many other SIDS, Seychelles was particularly affected by the COVID-19 crisis after March 2020, because of trade restrictions and new priorities set for passenger or freight transport (Kontovas and Sooprayen (2020), Rassool et al. (2020), IMF (2021), AfDB (2021)). A ban on international travel was implemented by the State with effect from 23 March 2020 until 30 July 2021. Cruise ship visits were also suspended indefinitely from February 2020 and extended until 2021 (Rassool et al. (2020)). The second half of 2020 was not better than the first one because most foreign countries where tourists originate had implemented a lockdown and restricted travelling abroad. The UNDP report estimated the impact of decreasing earnings from tourism before and after the pandemic, taking 2019 as the reference (Rassool et al. (2020), pp. 12).

We assumed that the structure of exports to non-resident tourists followed the contribution of tourism to GDP published by NBS (average 2014–2019, NBS (2021)). Four exporting industries would therefore be impacted: wholesale and retail trade, transportation and storage, administrative and support service activities, and accommodation and food services. We used the NBS survey on the number of visitors and the CBS survey on the estimated earnings from tourism <sup>(\*)</sup>. The number of visitors fell by 70 % in 2020 (114 858) compared with 2019 (384 204), with a corresponding 58 % decrease of foreign currency revenues (Figure 6). Assuming that the shock had exclusively affected the level of exports of the four above-mentioned industries, proportionately to their initial value, the new vector of final uses was introduced to simulate the new levels of CO<sub>2</sub> emissions.

<sup>(\*)</sup> On a monthly basis, the Central Bank of Seychelles collects accurate and comprehensive information about transactions captured from credit card systems in hotels, online bookings, restaurants, tourism-related transactions, destination management companies, ferries, and so on.



**Figure 6:** Number of visitors and estimated tourism expenditure per month, Seychelles, January 2014 to August 2021



Source: NBS (number of visitors); Central Bank of Seychelles (expenditure)

Total exports fell by 24 %, a little less than the IMF expectation which considered other affected industries. Obviously, the consumption-based CO<sub>2</sub> footprint did not change because it was assumed that none of the internal institutions had modified their consumption level. The emissions of domestic output directed to exports declined by 35 %. Overall, CO<sub>2</sub> emissions found in the national inventory fell by 16 %, from 900 000 tonnes to 752 000 tonnes. As expected, nearly two thirds of the 148 000 tonnes of CO<sub>2</sub> reduction of emissions were due to lower transportation, and 30 % to the decreasing use of accommodation and food services. It is important to remember that the external shock concerned only the tourism industry in this simulation, not other sectors affected by the pandemic. However, when looking at the actual figures for 2020, it appears that a few other key industries such as the fish processing industry have been weakly affected by the pandemic, exports even increasing in 2020 both in quantity and value.

## 5. Discussion of the results

### 5.1. Why is this CO<sub>2</sub> emission assessment useful for Seychelles?

Like many SIDS in the world, Seychelles is particularly vulnerable to the effects of global warming and very concerned by the international commitments of reduction taken after the Kyoto Protocol in 1997 and the 2007 Bali Action Plan (UNDP (2008), Burns and Vishan (2010), Nath and Madhoo (2021)). Considering the long-term effects of climate change as equivalent to an ENSO (El Niño Southern Oscillation) episode, global warming would cost several percentage points of GDP in the long run (Robinson et al. (2010)). Despite a very small contribution to global CO<sub>2</sub> emissions, Seychelles has to find pathways to reduce its ecological footprint by adapting its own patterns of production and consumption. First of all, this is the only means for the country to shift away from fossil fuel energy and transition to a more sustainable economy. Secondly, SIDS depend to a large extent on foreign trade: exports on the one hand for their foreign exchange income, and imports on the other for their intermediate and final consumption.

However, the comparative advantages of developing countries tend to concentrate locally the carbon emissions while developed countries can specialise in less polluting activities (Sannasse and Seetanah (2016)). Trade openness might be wealth-creating and provide foreign currency resources to a SIDS, but often at the expense of higher environmental costs. For example, it was shown econometrically for Mauritius that ‘a 1 % increase in trade openness is accompanied by an upshot of 0.60 % in CO<sub>2</sub> emission’ (Sannasse and Seetanah (2016), pp. 175). What is the need of exporting processed food products if the spillover effects are few for the country because of foreign shareholders, profits transferred to offshore companies, massive imports of inputs, and employment of foreign workers spending their income overseas? Why should final consumption of domestic households be based on imported processed products rather than local production? Even the steady growth of tourism, a pillar of economic development for the Seychelles, is questionable in terms of sustainability (Pratt (2015)). The increasing number of visitors (+120 % between 2010 and 2019, in other words an annual average growth rate of +9 %) results in greater air traffic and emissions, deforestation to build new resorts and accommodation capacity, privatisation of land and restricted access to beaches for the local population, foreign investment resulting in outflows of capital income, imports of many intermediate and final goods, more income inequalities, and so on. The assessment of carbon emissions may send the right signals to re-direct the country’s international specialisation (Sannasse and Seetanah (2016), Roth et al. (2019), Republic of Seychelles (2018)).

### 5.2. Which methodology for a replicable carbon assessment on a routine basis?

Two strands of methodology are usually distinguished to calculate CO<sub>2</sub> emissions from human activities. The first one is of microeconomic nature, with detailed information on household consumption and emission factors by type of commodity (Pasquier (2018)). The second one is more macroeconomic and combines inter-industrial data with national accounts on air

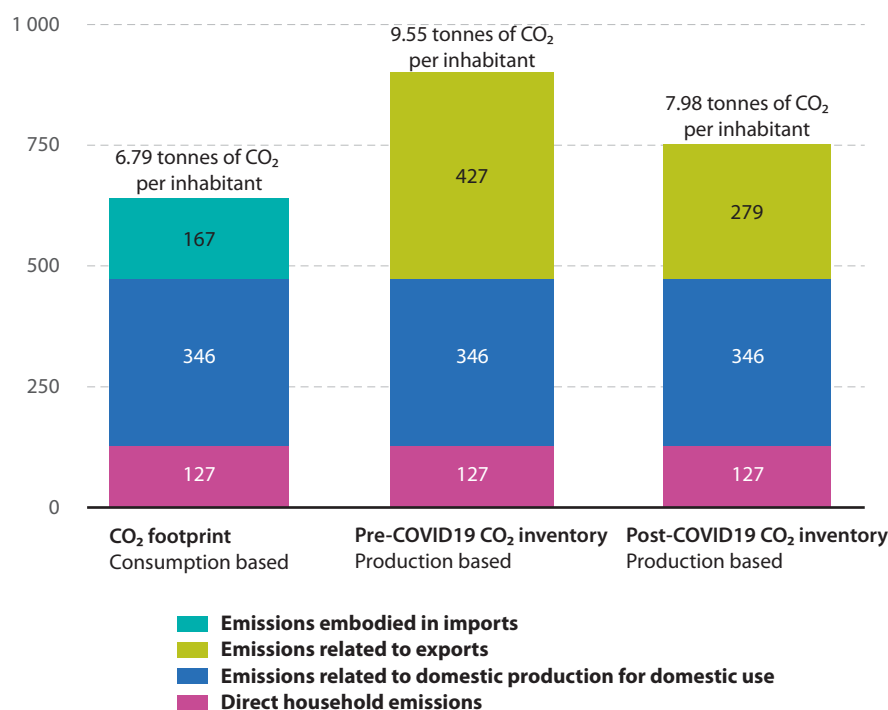
pollutant emissions (Suh (2009), Hertwich and Peters (2009), Boden et al. (2017)). The latter are rather based on a multi-regional framework, but can also be developed in a single-country framework (Miller and Blair (2009), Pasquier (2018), Boutaud and Gondrand (2018)). Differences of methodology and the level of detail may explain the divergence between the two types of approaches. For instance, the World Bank, using the CDIAC approach based on the multiregional GTAP model, found a CO<sub>2</sub> footprint per inhabitant of 6.32 tonnes for Seychelles in 2016 (data.worldbank.org), quite different from the value estimated the same year by the IEA with 5.43 tonnes (worldometers.com). Moreover, the first source provides a time series of CO<sub>2</sub> emissions with a very irregular pattern since 1971, following the booms and busts of the world economy, whereas the second one shows a more regular and increasing trend (see Figure 1). There is no absolute truth when it comes to the estimation of CO<sub>2</sub> emissions, but the least is to know how the calculation is made in order to simulate the effects resulting from major shocks affecting the economy, such as the COVID-19 pandemic for instance, or trade policy changes, and to reduce the overall level of air emissions.

In that respect, through the present contribution, we suggest to apply a widespread and transparent EE-IO methodology to the CO<sub>2</sub> footprint of Seychelles to serve as a reference basis for the coming years. Because there is no national account of air pollutant emissions yet, we used the EU air emission accounts database, which has the twofold advantage of being published online on a yearly basis and to cover the wide variety of EU Member States across different levels of industrial development and technology. Moreover, the EU is a major trade partner of the country, accounting for one third of imports and nearly 80 % of exports of goods, meaning that the technology structure materialised by the Leontief matrix and the air emission intensity could be fairly similar because the same environmental quality standards must be fulfilled by both partners.

### 5.3. Details about CO<sub>2</sub> emissions by origin and industry

The results show a CO<sub>2</sub> footprint of 513 000 tonnes of CO<sub>2</sub>, not including the direct emissions of households' vehicles and air conditioning personal systems for which we have no specific data yet (640 000 tonnes otherwise). This would represent an average amount of 5.44 tonnes of CO<sub>2</sub> per inhabitant (or 6.79 tonnes of CO<sub>2</sub> including direct emissions – left-hand column of Figure 7). These amounts are quite close to the IEA estimation of 502 000 tonnes (in other words, 5.33 tonnes of CO<sub>2</sub> per inhabitant), showing the reliability of the estimated outcome. They are also well above the worldwide average figure of 1.35 tonnes of CO<sub>2</sub> per inhabitant, a difference which is consistent with the economic status of Seychelles as a high-income country, with a GDP per inhabitant of USD 14 700 in 2014 (IMF (2021)). However, the national inventory, which includes the emission content of exports and excludes that embodied in imports, was 900 000 tonnes of CO<sub>2</sub> (in other words, 9.55 tonnes of CO<sub>2</sub> per inhabitant – middle column of Figure 7), exceeding the domestic footprint. As a comparison, the respective levels of national footprint and inventory in France are the opposite, showing a footprint greater than the inventory: 10.6 compared with 7.3 tonnes of CO<sub>2</sub> per inhabitant respectively (Boutaud and Gondran (2018)). Proportionately, France exports relatively less and imports relatively more goods than Seychelles.

**Figure 7: CO<sub>2</sub> footprint and inventory, Seychelles, 2019 (pre-COVID-19) and 2020 (post-COVID-19)**  
(1 000 tonnes of CO<sub>2</sub>)



Note: the emissions related to exports (green layer) do not include the import content of production; only the territorial emissions matter in the national inventory. The Seychelles population was 94 215 inhabitants in 2014 (Source: NBS 2021).

Source: own calculations

Another interest of the study is to disentangle the content of emissions by origin, either from imports or domestic production. This is important to show the gap between a production-based national inventory of CO<sub>2</sub> emissions and a consumption-based footprint where the responsibility of the country extends to the foreign nations where the commodities are produced (Wiebe and Yamano (2016), Boden et al. (2017), Wu et al. (2020)). The middle column of Figure 7 shows a great deal of CO<sub>2</sub> emissions related to exports, explaining that the level of emissions of the national inventory (900 000 tonnes of CO<sub>2</sub>, production-based) exceeds by far the footprint level (640 000 tonnes of CO<sub>2</sub>, consumption-based). Seychelles imports raw materials (for example, frozen tuna) that are further processed to be re-exported as final goods (canned tuna). The carbon emissions released by the fishing industry are imported but those included in the domestic output of canned fish products are exported, explaining why this important industry for Seychelles, representing 8 % of private jobs and 84 % of merchandise exports (NBS (2021)), does not appear among the most prominent industries captured by our estimated footprint in Section 4. Conversely, other industries like electricity and gas, public administration and defence, transportation and storage, wholesale and retail, administrative and support services are responsible for the national CO<sub>2</sub> footprint to a much greater extent because they reveal a pattern of domestic consumption.

## 6. Conclusion: towards a CO<sub>2</sub> abatement policy

On the basis of this first CO<sub>2</sub> footprint assessment, the government can take actions to reduce its footprint, mostly by substituting the fossil fuel origin of power used by inhabitants and local industries. It has started to do so, although at a slow pace, with an investment in renewable energy over the past decade. A 6 MW wind farm along with a 5.8 MW grid-tied roof top photovoltaic system supplied nearly 6 % of total electricity produced in 2020, the rest being provided by fossil fuels, mostly heavy fuel oil (PUC (2021)). The use of electric cars would be of little effect on direct household emissions as long as the electricity is carbon-based. A significant proportion of emissions related to domestic supply also comes from imports, through the transportation of goods (for example, food and beverage products) and the emissions embodied in foreign production. One type of abatement would stimulate the primary sectors of agriculture and fisheries, or promote other domestic sources of supply such as aquaculture to cover the local food demand of the population. Once again, the government has launched several actions to promote the ‘blue’ economy, developing coastal fisheries and aquaculture, or investing in blue bonds and marine renewable energy (Republic of Seychelles (2018)).

Another issue to deal with concerns the important content of emissions related to exports, whether they concern the tourism or the fish processing industries. We have shown that the national inventory (in other words, domestic emissions including the demand for exports) is greater than the national footprint. This is the case of many open economies like SIDS attempting to attract foreign exchange revenues, thus creating a livelihood for the population. Seychelles has been quite successful over the past decades to create an endogenous development of its economy through tourism (accommodation and food services, air traffic, support services such as tour operators, banking, arts and entertainment activities, and so on). However, the environmental cost could be important for Seychelles because this luxury industry relies to a great extent on imports and foreign investment, and the 2020 pandemic has also demonstrated the vulnerability of islanders with a strong decline (–70 % in 2020 compared with 2019) in the number of visitors (Rassool et al. (2020)). In this research, we have attempted to estimate the post-COVID impact on CO<sub>2</sub> emissions through the simulation of a 58 % decrease of expenditure from tourism that has been observed by the Central Bank of Seychelles in 2020. This would be equivalent to a 24 % reduction of total exports of goods and services for the country, resulting in a 16 % reduction of CO<sub>2</sub> emissions (right-hand column of Figure 7). Two thirds of this reduction of emissions would be obtained by the lower use of transportation services, and one third by the decreasing foreign demand for accommodation and food services.

This first attempt to estimate the CO<sub>2</sub> footprint of Seychelles by using a standard EE-IO approach has also several limitations, such as the lack of air emissions data monitored by the country, or the incomplete input–output table with regard to the distinction between domestic and imported intermediate consumption. Many efforts are under way to improve the data collection scheme, and a first supply and use table is now available and can be used to develop IO-based modelling and planning models (NBS (2021)). Further efforts are still needed prior to achieving a bigger MRIO framework, a social accounting matrix, a material flow analysis or a computable general equilibrium model, in order to trace more accurately the sinks and sources of carbon emissions, to assess other types of ecological footprints (for example, plastics) and find effective pathways of reducing outflows. At least this first estimation will serve as a transparent and replicable basis to follow the evolution of the CO<sub>2</sub> footprint and develop some mitigating projects for the country in a near future.

## 7. Acknowledgements

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## 8. Appendix

**Table A1: Domestic input–output table for 23 industries, Seychelles, 2014**  
(SCR million)

SPC	Intermediate uses											
	AA	AB	CA	CB	CC	CD	D	E	F	G	H	I
AA	16	0	2	23	6	0	0	0	4	5	2	152
AB	0	0	180	0	0	0	0	0	0	0	0	25
CA	0	0	1 513	0	0	0	0	0	0	1	1	77
CB	1	0	27	14	3	0	0	0	2	8	2	114
CC	0	0	0	1	29	0	0	0	0	8	1	121
CD	3	14	98	3	25	48	121	11	212	39	153	51
D	3	4	24	8	24	6	3	65	25	95	51	300
E	0	0	1	0	1	0	1	2	1	17	4	12
F	1	1	25	1	5	7	4	4	81	26	39	47
G	0	0	0	0	0	0	0	0	0	0	0	0
H	2	3	241	4	16	12	0	8	49	170	571	78
I	1	1	7	0	7	2	0	4	2	17	124	53
J	1	1	18	1	5	6	0	3	12	36	50	60
K	19	4	20	1	3	5	0	4	42	68	53	115
LA	5	9	6	6	5	15	1	2	32	259	112	114
LB	0	0	0	0	0	0	0	0	0	0	0	0
M	0	0	41	1	5	2	0	1	7	19	12	74
N	2	3	23	1	1	2	3	8	5	40	221	38
O	2	4	33	1	2	3	0	2	7	15	13	54
P	1	2	15	0	1	1	0	1	3	9	6	25
Q	0	1	6	0	0	0	0	0	1	3	2	10
R	0	0	3	0	0	0	0	0	1	3	1	18
S	0	0	0	0	0	0	0	0	0	0	0	0
Total domestic intermediate consumption	59	47	2 286	66	137	110	135	117	486	838	1 417	1 538
Imports	44	98	1 570	100	215	336	811	86	1 476	465	1 402	1 312
Taxes on products	33	11	6	148	598	1 152	0	0	20	0	17	718
Gross value added	220	192	811	30	270	174	344	84	1 076	1 119	1 200	2 037
Output	356	349	4 673	344	1 220	1 772	1 289	286	3 058	2 422	4 035	5 605

**Table A1 (cont.): Domestic input–output table for 23 industries, Seychelles, 2014**  
(SCR million)

SPC	Intermediate uses										
	J	K	LA	LB	M	N	O	P	Q	R	S
AA	0	0	0	0	0	0	0	0	0	0	0
AB	0	0	0	0	0	0	0	0	0	0	0
CA	0	0	0	0	0	0	0	0	0	0	0
CB	0	0	0	0	0	0	0	0	0	0	0
CC	0	0	3	0	0	0	0	0	0	1	0
CD	36	8	22	0	3	15	35	4	25	18	10
D	37	7	86	0	3	10	91	25	14	18	7
E	1	0	3	0	0	0	78	4	2	4	0
F	22	28	17	0	9	10	109	18	1	17	5
G	0	0	0	0	0	0	0	0	0	0	0
H	10	5	26	0	9	456	45	3	5	14	4
I	23	4	3	0	3	2	57	18	31	4	0
J	7	23	26	0	6	17	49	11	6	8	6
K	13	136	142	0	5	30	30	5	19	18	4
LA	67	64	33	0	25	31	86	1	45	21	22
LB	0	0	0	0	0	0	0	0	0	0	0
M	42	59	12	0	26	9	39	4	2	3	1
N	7	32	32	0	3	4	169	19	2	8	1
O	9	17	10	0	5	6	5	3	2	5	2
P	5	8	5	0	2	3	12	5	1	3	1
Q	2	3	2	0	1	1	1	1	21	1	0
R	1	2	1	0	0	1	8	0	0	1	0
S	0	0	0	0	0	0	0	0	0	0	0
Total domestic intermediate consumption	280	396	423	0	100	594	816	121	178	143	64
Imports	401	301	236	0	123	310	489	53	179	144	74
Taxes on products	175	6	30	0	0	36	0	0	2	55	10
Gross value added	596	733	581	1 562	317	421	1 656	552	369	199	125
Output	1 452	1 436	1 271	1 562	540	1 361	2 961	726	728	542	273



**Table A1 (cont.): Domestic input–output table for 23 industries, Seychelles, 2014**  
(SCR million)

SPC	Final uses				
	Household	Government	Investment	Exports	Total uses
AA	116	0	0	30	356
AB	143	0	0	0	349
CA	9	0	0	3 072	4 673
CB	127	0	0	44	344
CC	827	0	0	230	1 220
CD	205	0	338	275	1 772
D	382	0	0	0	1 289
E	154	0	0	0	286
F	89	0	2 444	48	3 058
G	1 300	0	0	1 123	2 422
H	342	0	0	1 964	4 035
I	551	0	0	4 690	5 605
J	602	44	0	453	1 452
K	157	83	0	459	1 436
LA	143	0	0	167	1 271
LB	1 562	0	0	0	1 562
M	0	0	0	180	540
N	735	0	0	0	1 361
O	18	2 743	0	0	2 961
P	186	430	0	0	726
Q	194	477	0	0	728
R	430	71	0	0	542
S	273	0	0	0	273
Total domestic intermediate consumption					
Imports	2 844	21	2 343	4 766	
Taxes on products					
Gross value added					
Output	11 389	3 869	5 125	17 504	

**Table A1 (cont.): Domestic input–output table for 23 industries, Seychelles, 2014**  
(SCR million)

SPC	
<b>AA</b>	Agriculture
<b>AB</b>	Fishing
<b>CA</b>	Manufacture of fishery products
<b>CB</b>	Manufacture of other food
<b>CC</b>	Manufacture of beverage and tobacco
<b>CD</b>	Manufacturing, other
<b>D</b>	Electricity, gas, steam and air conditioning supply
<b>E</b>	Water supply; sewerage, waste management
<b>F</b>	Construction
<b>G</b>	Wholesale and retail trade; repair of motor vehicles
<b>H</b>	Transportation and storage
<b>I</b>	Accommodation and food service activities
<b>J</b>	Information and communication
<b>K</b>	Financial and insurance activities
<b>LA</b>	Real estate activities
<b>LB</b>	Owner occupied dwellings
<b>M</b>	Professional, scientific and technical activities
<b>N</b>	Administrative and support service activities
<b>O</b>	Public administration and defence
<b>P</b>	Education
<b>Q</b>	Human health and social work activities
<b>R</b>	Arts, entertainment and recreation
<b>S</b>	Other service activities

**Table A2: CO<sub>2</sub> emission coefficients for 23 industries, Seychelles, 2014**  
(1 000 tonnes of CO<sub>2</sub> per SCR million of output)

	$e_j^e$ EU-27	$e_j^d$ Seychelles
Agriculture	0.0135	0.0335
Fishing	0.0323	0.0798
Manufacture of fishery products	0.0031	0.0075
Manufacture of other food	0.0031	0.0075
Manufacture of beverage and tobacco	0.0031	0.0075
Manufacturing, other	0.0110	0.0272
Electricity, gas, steam and air conditioning supply	0.0936	0.1870
Water supply; sewerage, waste management	0.0067	0.0164
Construction	0.0018	0.0045
Wholesale and retail trade; repair of motor vehicles	0.0016	0.0040
Transportation and storage	0.0325	0.0803
Accommodation and food service activities	0.0014	0.0035
Information and communication	0.0005	0.0013
Financial and insurance activities	0.0003	0.0007
Real estate activities	0.0002	0.0004
Owner occupied dwellings	0.0000	0.0000
Professional, scientific and technical activities	0.0006	0.0015
Administrative and support service activities	0.0009	0.0022
Public administration and defence	0.0014	0.0035
Education	0.0013	0.0031
Human health and social work activities	0.0011	0.0028
Arts, entertainment and recreation	0.0013	0.0033
Other service activities	0.0012	0.0029

Note: the EU-27 values are the intensity coefficients of CO<sub>2</sub> emissions per unit of output value, expressed in 1 000 tonnes of CO<sub>2</sub> per € million (from Eurostat NAMEA data, <https://ec.europa.eu/eurostat/>) and converted in 1 000 tonnes of CO<sub>2</sub> per million Seychelles rupees with an exchange rate of 16.96 (CBS rate in 2014). The Seychelles emission rate is the EU-27 coefficient adjusted for Africa with regard to the IEA deviation coefficients of 2.47 for non-electrical industries and 2.00 for the electricity sector.

## 9. References

- AfDB (2021), *African Economic Outlook 2021 – From Debt Resolution to Growth: the Road Ahead for Africa*, African Development Bank Group, Abidjan.
- Ahmad, N. and A. Wyckoff (2003), 'Carbon Dioxide Emissions Embodied in International Trade of Goods', *Science Technology and Industry Working Papers*, 2003/15, OECD, Paris.
- Aichele, A. and G. Felbermayr (2012), 'Kyoto and the carbon footprint of nations', *Journal of Environmental Economics and Management*, Volume 63, Issue 3, pp. 336–354.
- Archer, B. and J. Fletcher (1996), 'The economic impact of tourism in the Seychelles', *Annals of Tourism Research*, Volume 23, Issue 1, pp. 32–47.
- Boden, T. A., G. Marland and R. J. Andres (2017), *Global, Regional, and National Fossil-Fuel CO<sub>2</sub> Emissions*, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn.
- Boutaud, A. and N. Gondran (2018), *L'empreinte écologique*, Editions La Découverte, Paris.
- Brown, N. (Ed.), M. Berglund, M. Bivred, M. Gray and S. Nakamura (2021), *Producing environmental accounts with environmentally extended input output analysis – 2021 edition*, Statistical Working Papers, Eurostat, Luxembourg.
- Burns, P. M. and I. Vishan (2010), 'The Changing Landscape of Climate Change: NAMAs, SIDS and Tourism', *Tourism and Hospitality Planning & Development*, Volume 7, Issue 3, pp. 317–328.
- Chassot, E., S. Antoine, P. Guillotreau, J. Lucas, C. Assan, M. Marguerite and N. Bodin (2021), 'Fuel consumption and air emissions in one of the world's largest commercial fisheries', *Environmental Pollution*, Volume 273, Article 116454.
- Crippa, M., D. Guizzardi, E. Solazzo, M. Muntean, E. Schaaf, F. Monforti-Ferrario, M. Banja, J. Olivier, G. Grassi, S. Rossi and E. Vignati (2021), 'GHG emissions of all world countries', EUR 30831 EN, Publications Office of the European Union, Luxembourg.
- Gajos, E. and K. Prandecki (2016), 'National Accounting Matrix with Environmentally Extended IO analysis', *Oeconomia*, Volume 15, Issue 4, pp. 65–74.
- Guillotreau, P., L. Campling and J. Robinson (2012), 'Vulnerability of small island fishery economies to climate and institutional changes', *Current Opinion in Environmental Sustainability*, Volume 4, Issue 3, pp. 287–291.
- Hallegatte, S. (2009), 'Strategies to adapt to an uncertain climate change', *Global Environmental Change*, Volume 19, Issue 2, pp. 240–247.
- Hertwich, E. G. and G. P. Peters (2009), 'Carbon Footprint of Nations: A Global, Trade-linked Analysis', *Environmental science & technology*, Volume 43, No. 16, pp. 6 414–6 420.
- Hertwich, E. G. and G. P. Peters (2010), *Multiregional Input–Output Database, One Planet Economy Network (OPEN): EU Technical Document*, Trondheim.

IMF (2021), *World Economic Outlook Update*, January 2021.

Kelman, I. (2018), 'Islandness within climate change narratives of small island developing states (SIDS)', *Island Studies Journal*, Volume 13, Issue 1, pp. 149–166.

Kim, N. (2020), 'How long will it take for LDCs and SIDS to recover from the impacts of COVID-19?', *DESA Working Paper No. 170*, Department of Economic and Social Affairs, United Nations.

Kontovas, C. A. and K. Sooprayen (2020), 'Maritime Cargo Prioritisation during a Prolonged Pandemic Lockdown Using an Integrated TOPSIS-Knapsack Technique: A Case Study on Small Island Developing States — The Rodrigues Island', *Sustainability*, Volume 12, Issue 19.

Leontief, W (1970), 'Environmental repercussions and the economic structure: an input–output approach', *The Review of Economics and Statistics*, Volume 52, No. 3, pp. 262–271.

Miller, R. E. and P. D. Blair (2009), *Input–Output Analysis, Foundations and Extensions*, Cambridge University Press, 2nd ed., Cambridge.

Moran, D. and R. Wood (2014), 'Convergence between the Eora, WIOD, EXIOBASE, and OpenEU's consumption-based carbon accounts', *Economic Systems Research*, Volume 26, Issue 3, pp. 245–261.

Nath, S. and Y. N. Madhoo (2021), 'Climate Change, Sea Level Dynamics, and Mitigation' in *Shaping the Future of Small Islands – Roadmap for Sustainable Development*, Palgrave Macmillan, Singapore, pp. 185–203.

NBS (2021), *Supply and Use Table 2014*, Annual National Accounts, Employment & Earnings; [www.nbs.gov.sc](http://www.nbs.gov.sc).

Pasquier, J.-L. (2018), *Méthodologie de calcul de l'empreinte carbone de la demande finale intérieure française*, Commissariat Général au Développement Durable, SDES-SDIE, Document de Travail.

Pratt, S. (2015), 'The economic impact of tourism in SIDS', *Annals of Tourism Research*, Volume 52, pp. 148–160.

PUC (2021), *Annual report FY 2021*, Public Utilities Corporation, Mahé; [www.puc.sc](http://www.puc.sc).

Rassool B., B. Vel, E. Twimukye, L. Navarro, T. Muhumuza and R. Alcindor (2020), *An assessment of the socio-economic impact of Covid-19 in Seychelles*, Government of Seychelles, United Nations Development Programme Seychelles.

Republic of Seychelles (2018), *Seychelles Blue Economy: Strategic Policy Framework and Roadmap: Charting the future (2018–2030)*.

Robinson, J., P. Guillotreau, R. Jiménez-Toribio, F. Lantz, L. Nadzon, J. Dorizo, C. Gerry and F. Marsac (2010), 'Impacts of climate variability on the tuna economy of Seychelles', *Climate Research*, Volume 43, Issue 3, pp. 149–162.

Robinson, S. A. (2020), 'Climate change adaptation in SIDS: A systematic review of the literature pre and post the IPCC Fifth Assessment Report', *Wiley Interdisciplinary Reviews Climate Change*, Volume 11, Issue 4.

Roth N., T. Thiele and M. von Unger (2019), *Blue Bonds: Financing resilience of coastal ecosystems*, report prepared for IUCN GMPP by 4Climate, Global Ocean Trust and Silvestrum.

Sannasse, R. V. and B. Seetanah (2016), 'Trade openness and CO<sub>2</sub> emission: evidence from a SIDS' (Chapter 9) in *Handbook of environmental and sustainable finance*, Academic Press, pp. 165–177.

Suh, S. [ed.] (2009), *Handbook of Input–Output Economics in Industrial Ecology*, Springer.

Valenghi, J.-P. (2004), *Sustainable Development in the Seychelles: Economic effects of possible tourism development scenarios for the Seychelles*, University of Zürich, Zürich.

Wiebe, K. and N. Yamano (2016), 'Estimating CO<sub>2</sub> Emissions Embodied in Final Demand and Trade Using the OECD ICIO 2015: Methodology and Results', *OECD Science, Technology and Industry Working Papers 2016/05*, OECD Publishing, Paris.

Wiedmann, T., H. C. Wilting, M. Lenzen, S. Lutter and V. Palm (2011), 'Quo Vadis MRIO? Methodological, data and institutional requirements for multi-region input–output analysis', *Ecological Economics*, Volume 70, Issue 11, pp. 1 937–1 945.

WTO (2020), *Trade set to plunge as COVID-19 pandemic upends global economy*, World Trade Organization press release, 8 April 2020.

Wu, X. D., J. L. Guo, C. Li, G.Q. Chen, and X. Ji (2020), 'Carbon emissions embodied in the global supply chain: Intermediate and final trade imbalances', *Science of The Total Environment*, Volume 707.

Zheng, D. and M. Shi (2017), 'Multiple environmental policies and pollution haven hypothesis: Evidence from China's polluting industries', *Journal of Cleaner Production*, Volume 141, pp. 295–304.

