Travel and Greenhouse Gas Emissions

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Carbon Footprints and Carbon Offsetting of U.S. Education Abroad Air Travel

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Education Abroad's Climate Impact

US students participated in more than 3,47,000 study abroad experiences in the 2018–2019 academic year to destinations on all continents, according to the Institute of International Education's Open Doors report (2020). Study abroad is well recognized as a high-impact practice for developing global and intercultural awareness, expanding horizons academically, and, especially in recent years, gaining international professional experience. However, the majority of these experiences require students to fly internationally, a practice known to emit large quantities of carbon dioxide (CO_2) into our atmosphere (Lee *et al.*, 2021) and contribute to anthropogenic climate change. The environmental and climate impacts of study abroad have only relatively recently started to receive significant attention within the education abroad sector (Hale, 2019; Redden, 2019; de Wit and Altbach, 2020). The Forum on Education Abroad recently released a set of guidelines for advancing the United Nations Sustainable Development Goals, including climate action, in an education abroad context (Forum on Education Abroad, 2021).

This chapter presents some estimates of the carbon emissions from U S study abroad air travel in an effort to understand how much carbon is generated by education abroad so that we can establish a baseline against which the field can benchmark itself and to then properly target reduction efforts. It also outlines some strategies that U S students, colleges, and study abroad programs can implement to offset this carbon contribution in an effort to become more sustainable.

Carbon Footprints and Carbon Calculators

A carbon footprint is the measure of the carbon emissions relating to an activity, expressed as a mass of carbon dioxide (CO_2) emitted or as carbon dioxide equivalent (CO_2-eq) if the climate impacts of other greenhouse gas emissions are also included. The activity under consideration could be on various scales, so we can estimate carbon footprints for countries, industries, houses, campuses, events, and even personal carbon footprints based upon our lifestyles and activities. The average person on Earth has a carbon footprint of slightly less than 5 metric tonnes of CO_2 (World Bank, 2019), while the average per capita carbon footprint for the United States is significantly higher than the global average, at approximately 15.5 metric tonnes (Crippa *et al.*, 2020). Air travel is a significant contributor to global CO_2 emissions, accounting for about 2.4% of human-induced global emissions (Graver *et al.*, 2019). According to Shields (2019), global student mobility contributes between 14.0 and 38.5 megatonnes of CO_2-eq per year, depending on model assumptions. Hale (2019) estimated that student exchange travel involving the United States (outbound US students and inbound international students) results in a carbon footprint of 2.5 megatonnes of CO_2 per year.

The estimation of the carbon footprint of study abroad flights can be generally conducted in one of two ways, depending on whether bulk data in passenger kilometers (or miles) or individual flight data using origin, destination, and routing are to be used. Most international education offices would have information on the number of students sent to various destinations, but they often would not know the class of service, route, or connections the student took to get there. In this 'bulk data' situation, the best approximation is often to calculate a sum of passenger distance flown, often assuming a direct flight, and then multiply by a published conversion factor (Table 12.1) to arrive at the total CO_2 emitted as that passenger's share of the flight. These conversion factors are averages taking into account influences such as aircraft types, fuel consumption, average passenger loads, passenger-to-cargo ratios, and average time spent in non-direct flights for situations such as avoiding storms or circling airports (termed 'distance uplift', usually adding 8–10% to flight carbon footprint), but are not specific to any routing, flight distance, or region. However, this type of calculation likely underestimates

Table 12.1 Conversion of passenger distance flown to CO_2 emissions for bulk data air travel calculations. Values used for calculations in this chapter are noted with *

Source	kg CO_2 per passenger kilometer (mile)	Emissions weighting factor owing to high-altitude emissions
United States Environmental Protection Agency	0.099 (0.16)*	–
DEFRA (UK) – short haul – flights UK to Europe	0.083 (0.133)	1.89
DEFRA (UK) – long haul to/from UK	0.102 (0.164)	1.89
DEFRA (UK) – International to/from non-UK	0.095 (0.153)	1.89
Cox and Althaus (2019)	–	1.83 (flights of 2,000 km)
IPCC (2007)	–	2.7
Jungbluth and Meili (2019)	–	2.0 *
Atmosfair (2016)	–	3.0 for a portion of flight >9,000 m altitude

the true carbon footprint as it often assumes direct flights to the end destination. Calculations in this chapter use the US EPA's recommendation of 0.099 kg CO_2 per passenger kilometer (0.16 kg CO_2 per passenger mile) when bulk distance data is used. Other commonly used conversion factors are summarized in Table 12.1.

The carbon footprint for individual flights can easily be estimated using the above method or one of the many calculators available on the internet using origin, destination, connecting airports, and a class of service as inputs. An estimated carbon footprint per passenger for the flight is returned as a result. In contrast to the bulk processing noted above, these carbon calculators most often use data specific to each route, including aircraft types, fuel consumption, cargo-to-passenger ratios, average passenger loads, and average time spent in non-direct flights for situations such as avoiding storms or circling airports. It should also be noted that not all carbon calculators will return the same result owing to a significant number of assumptions that need to be included (Padgett *et al.*, 2008; Guardian, 2008), and all results returned from a calculator should be considered an estimate. It is best to look for a calculator from a well-established organization with robust documentation. Examples of these calculators include those from the International Civil Aviation Organization (ICAO, 2021), myclimate (2019), or Atmosfair (2016). The ICAO calculator does not include radiative forcing factors in its result (see below), while both myclimate and Atmosfair do but use different values and assumptions and thus will give different overall results for the same flight. It should also be noted that many calculators, including myclimate and Atmosfair, tend to return higher carbon footprint results for individual flights than either the bulk processing method or the ICAO calculator, even with radiative forcing factors included. This chapter uses the ICAO calculator and multiplies each flight separately by a radiative forcing factor of 2.0 (see below) when estimating the carbon footprint of individual flights.

Studies (Fromming *et al.*, 2012; Lee *et al.*, 2021) have shown that the combustion of fuel at high altitudes, such as those during international flights, has a greater climate impact than combustion at ground level. This is due to non-CO_2 warming pollutants, such as water vapor, aerosols, and nitrogen oxides, being produced, along with the development of contrails. A multiplying radiative forcing (RF) factor needs to be included in the calculations (Jungbluth and Meili, 2019), which thus results in a measure expressed in CO_2-eq. This multiplying factor is commonly either 1.89 as suggested by DEFRA (UK), 2.7 as suggested by SIMAP based on IPCC (2007), or 3.0 for all flight time at greater than 9,000 m suggested by Atmosfair (2021). Cox and Althaus (2019) showed that the emissions weighting factor varies with flight length, with longer flights with a greater proportion of time spent at cruising altitude having larger factors. They suggest an emissions weighting factor of 1.83 for flights of 2000 km. Jungbluth and Meili (2019), in an analysis of radiative forcing factors in the literature, note that there is currently no scientific consensus but recommend a factor of 2.0. The calculations in this chapter follow Jungbluth and Meili's (2019) recommendation of an RF factor of 2.0.

As mentioned above, there are several methods for estimating the carbon footprint of flights, and each will give a different result. Flight carbon calculators such as myclimate or Atmosfair tend to return higher carbon emission estimates than the bulk data method used extensively in this paper and in Shields (2019) and Hale (2019). Bulk data estimations are used widely in this chapter primarily owing to the type of available data, that is, numbers of students and destinations, without any indication as to the exact routing to the destination, aircraft type, class of service, or typical passenger or cargo loading on the route as incorporated into the calculations of the individual flight calculators. With this in mind, it is believed that the calculations presented in this chapter represent an estimate of the low end of the true carbon footprint of US education abroad flight carbon footprint as a sector. A carbon calculator developed specifically for individual flights, such as myclimate, Atmosfair, or the ICAO calculator, should be used in those cases and will likely return a greater estimated carbon footprint.

Estimating US Study Abroad's Global Flight Carbon Footprint

It is possible to estimate the total carbon footprint of flights owing to US study abroad globally through the use of data from the Institute of International Education's Open Doors report (2020) and the carbon calculations listed above. IIE (2020) data consists simply of the number of US students who studied abroad in a foreign country in a given year and does not include the US departure or destination airports. For the purposes of this carbon footprint estimation, flight distances are calculated based on assuming students departed from St. Louis, the closest international airport to the population center of the United States, and flew on a direct flight to the capital city of the country in which they were studying abroad. The assumption of all students originating from the population center of the United States as a departure city averaging effect does not capture any regional differences in US education abroad that may exist (i.e., students from one US region preferentially studying abroad in a certain destination or region, or study abroad participation rates being higher in particular US regions), or if the students flew out of the location of their institution or of their usual home. Additionally, the assumption that direct flights were available and taken very likely results in an underestimate of the total passenger distance flown.

While more than 347,000 students studied abroad in 2018/19, slightly more than 26,000 of those traveled to multiple countries on the same overseas trip, the location of which is not included in the Open Doors data. Thus, we calculate the total study abroad passenger miles as the known country destination of 321,025 students using the methodology above and consider the remaining 26,074 students as having traveled the weighted average distance of those with known destinations.

Using this approach, it is estimated that the 347,099 U.S. study abroad students flew a combined 5.57 billion kilometers, round trip, for their study abroad experience, or an average of 16,043 kilometers per student (Table 12.2). Using conversions of 0.099 kg CO_2 per passenger kilometer and a high-altitude combustion radiative forcing factor of 2.0, this results in an estimated total of 1,102,535 metric tonnes of CO_2-eq (or 1.103 megatonnes) emissions for U.S. study abroad traveling to and from their abroad destination for the 2018–19 academic year. The estimated carbon footprint per student is 3.176 metric tonnes of CO_2-eq. Again, based on the bulk data calculation method being used, it is believed that these values represent an estimate on the low end of the true estimated flight carbon footprint for the sector, and if calculators for individual flights were used, the estimates would be greater.

Table 12.2 The estimated carbon footprint of U.S. study abroad by region. Data for student numbers from the Institute of International Education's Open Doors report (2020) for the 2018–19 academic year. Travel distance is calculated assuming all student flights originate in St. Louis, the closest international airport to the population center of the United States, flying direct to the capital city of their destination country. Conversions to the estimated carbon footprint use conversions of 0.099 kg CO_2 per passenger km and a high-altitude radiative forcing multiplier of 2.0. See text for further details.

Destination region	Number of students (2018–19)	Estimated total round trip km flown	Estimated carbon footprint (metric tonnes CO_2-eq including RF = 2.0)	Estimated carbon footprint (megatonnes CO_2-eq including RF = 2.0)
Europe	193,422	2,850,755,824	564,450	0.564
Asia	40,602	948,271,337	187,758	0.188
Oceania, incl. Antarctica	15,520	438,630,139	86,849	0.087
Africa	15,495	372,849,963	73,824	0.074
South America	18,300	243,845,636	48,281	0.048
North America, Central American and Caribbean	31,761	168,707,083	33,404	0.033
Middle East	5,925	127,018,463	25,150	0.025
Multi-destination	26,074	418,279,108	82,819	0.083
TOTALS	**347,099**	**5,568,357,554**	**1,102,535**	**1.103**
Average per student		**16,043**	**3.176**	

Table 12.3 shows the estimated study abroad flight carbon footprints for the 10 most popular U.S. study abroad global destinations. While the United Kingdom hosts the most students, the carbon footprint of study abroad flights is the greatest for Italy owing to the greater distances flown to and from the study abroad site.

Students studying abroad often find themselves living in a country in which the per capita CO_2 emissions are lower than those of the average American, whose emissions amount to 15.5 metric tonnes per capita (Crippa *et al.*, 2020), although the usual lifestyle of U.S. students may be lower than that of the average American. It then stands to reason that a student living the same carbon lifestyle as a local resident while on their study abroad experience could theoretically offset the carbon cost of their flight after a certain time period. Calculations presented in Table 12.3 indicate that a student living the consumption lifestyle of the average Costa Rican would offset their flight carbon emissions after 34 days in the country, living like a local. Students studying abroad in most European destinations could have offset their flight carbon emissions in about the span of one semester, and students

Table 12.3 Total estimated flight carbon footprint of U.S. study abroad to the top 10 global destinations. Per capita production-based emissions from Crippa *et al.* (2020) are used to estimate the number of days 'living like a local' required to offset the carbon footprint of flights to and from the study abroad destination.

Top 10 study abroad destinations	Study abroad students 2018–19	Estimated round trip distance (km)	Estimated total carbon footprint of study abroad flights (metric tonnes CO_2-eq)	Per capita CO_2 emissions using production-based accounting methods (metric tonnes)*	Estimated number of days in the country required to offset student flight when following a local lifestyle
United Kingdom	39,358	13,580	105,827	5.45	97
Italy	39,043	16,351	126,402	5.60	119
Spain	33,849	14,252	95,518	5.58	104
France	18,465	14,156	51,755	4.81	96
Germany	12,029	15,067	35,886	8.52	156
Ireland	11,777	12,620	29,428	7.54	114
China	11,639	21,713	50,038	8.12	212
Australia	10,665	29,609	62,524	17.27	–
Japan	8,928	20,603	36,421	9.10	232
Costa Rica	8,333	6,489	10,706	1.80	34

* production-based carbon emission accounting includes in-country generated emissions only and ignores the production of goods elsewhere for subsequent importation (Franzen and Mader, 2018). For countries that rely heavily on imports, such as Ireland in this listing, this method results in an underestimation of carbon emissions per capita for that country compared to consumption-based carbon accounting.

studying abroad in Australia cannot offset in this manner as the per capita emissions are greater (17.27 metric tonnes) than those of the United States.

This analysis in no way suggests that flight carbon emissions should be considered as offsets using this method, partially because for many locations, it may be rare for a student to fully adopt a local lifestyle but is simply pointing out that life in many study abroad destinations is of lower carbon intensity, and the promotion of 'living like a local' can often have a significant impact. This may include being housed in homestays, using public transportation or walking, shopping for locally-sourced products, and limiting airline travel during academic breaks. This type of calculation also highlights that longer-term study abroad programmes (e.g., semester length) can be considered to have a lower carbon footprint compared to shorter-term programmes, as long as students are living a carbon lifestyle while on site that is lower than their footprint in the United States Some authors have even called for universities and funding agencies to drastically reduce student mobility on short-term programmes (de Wit and Altbach, 2020) owing to their carbon impact.

Independent Student Travel While On-Site

Students most often study abroad in a set location but often use that location as a hub for travel at weekends and over academic break periods independent of the program. Off-program independent travel is common on European study abroad programs, where inexpensive flights can often be found.

In a survey conducted by the authors in April 2021, 23 European study abroad Resident Directors reported with fairly high confidence that students averaged 5.6 round trip flights within Europe (range: 1–12) during their semester abroad. Response data either came from travel details filed by students for emergency response reasons or from estimates based on years of experience running abroad programs. Most commonly, students traveled by flight outside of the country of their program, with the most popular destinations being London, Barcelona, Paris, Dublin, and Rome. Students abroad for periods less than a semester were estimated to take 1.7 additional round trip flights within Europe independent of their program (range: 0–4). These European study abroad leaders also reported an estimate that, on average, 26% of overnight non-program trips taken by students were by more environmentally friendly travel methods, such as train or bus. Some students may also arrive early in the host region, or stay after the program ends, in order to travel. This type of pre- and post-program travel remains unaccounted for in any estimates.

While these data only represent estimates from program leaders and not directly from the students themselves, it is apparent that there is a significant carbon footprint associated with independent travel while on a study abroad program, at least in the European context.

A student taking 5 independent trips from Madrid, a popular study abroad host city, to each of the five most popular independent destinations listed above, would accumulate a carbon footprint of 2,257 kg CO_2-eq for those trips (using ICAO's calculator and an RF factor of 2.0), significantly greater than the carbon footprint of the round-trip flight from St. Louis to Madrid, via Chicago, of 1,757 kg CO_2-eq, to actually be on the program.

This suggests that the carbon footprint of student independent travel while on a semester program may be at least equal to, and likely greater than that of the flights taken to attend the program, at least in the case of European study abroad. It should be noted that only about 35% of U.S. study abroad students spend a semester or more abroad (Open Doors, 2020), with the remainder participating in shorter programs where there may be a decreased opportunity for independent travel.

Study Abroad Carbon Footprints as a Proportion of the Whole-Campus Carbon Footprint

Many U.S. campuses estimate the carbon footprint of their physical campus and their activities, and in some cases, this reporting includes student study abroad travel. Campus carbon emissions calculation and reporting follow a standard that is broken down into emission sources, or Scopes. Scope 1 covers direct emissions from owned or controlled sources, and Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating, and cooling consumed by the institution. Scope 3 includes all other indirect emissions that occur outside of a campus's immediately controlled operations and, where reported, includes carbon associated with university-sponsored study abroad. Most institutions restrict air travel reporting to directly financed air travel, and some, but certainly not all, also include study abroad air travel as a category under Scope 3 reporting. It is thought that Scope 3 carbon is underreported by many institutions.

Using institution-reported data in the University of New Hampshire's Sustainability Indicator Management and Analysis Platform (SIMAP) database, Table 12.4 shows the percent of overall campus operations carbon footprint that is attributed to study abroad travel from 113 doctoral, masters, baccalaureate, and associate and tribal college institutions in the United States that report study abroad flight information.

The median estimated footprint of study abroad flight carbon is greatest for doctoral institutions, yet this footprint represents a lower percentage of the overall campus carbon footprint than for master's or baccalaureate institutions. Study abroad flight carbon estimates are significantly lower for associates and tribal college institutions. Study abroad flight carbon contributes a median of 855.5 metric tonnes of CO_2-eq per institution and represents a median of 3.1% of the overall campus carbon footprint for the 113 institutions.

Converting Study Abroad Carbon Footprints to More Meaningful Measures

Presenting carbon footprint data in terms of CO_2-eq is very useful in an accounting sense, but many people will struggle with conceptualizing this relatively abstract number in terms of real-world impacts.

The U.S. Environmental Protection Agency (2021a) provides a calculator intended to convert carbon dioxide equivalent emissions into more easily understood, concrete terms. Table 12.5 provides a sampling of results from this calculator.

Table 12.4 The median and range of institutional study abroad carbon footprints and percentage of the total campus carbon footprint attributed to study abroad flights based on Carnegie classification for 113 U.S. institutions. Several institutions with strong study abroad participation are found in each classification dataset and skew the data. For this reason, median data is presented. Data was reported from 2016 to 2019 to the Sustainability Indicator Management and Analysis Platform (SIMAP) database by the University of New Hampshire and is used here with permission. The most recently reported year for each institution was used in the calculations. Any data reported for 2020 was not used owing to the significant decline in study abroad air travel due to COVID-19. Note that while original SIMAP data used a radiative forcing (RF) factor of 2.7, this data has been converted to use a RF of 2.0 for use in this chapter.

Institution type	Institutional study abroad flight carbon footprint in metric tonnes CO_2-eq; median (range)	Study abroad carbon footprint as percent of total campus carbon footprint; median (range)
Associates and Tribal Colleges (n=11)	28.7 (2.0–580.8)	0.12% (0.01–1.1%)
Baccalaureate (n=38)	546.3 (1.4–6,530.1)	3.6% (0.01–14.9%)
Master's (n=30)	1,163.0 (2.5–3,007.6)	3.6% (0.1–15.9%)
Doctoral (n=34)	2,392.1 (27.6–9,700.2)	2.4% (0.05–13.8%)
All Institutions (n=113)	855.5 (1.4–9,700.2)	3.1% (0.01–15.9%)

Table 12.5 Carbon footprint conversions to other measures using the carbon equivalencies calculator from the U.S. EPA (2021a). Conversions are from the footprints of (a) the estimated average study abroad student flight carbon footprint to and from the abroad site (Table 12.2), (b) the estimated median study abroad flight carbon footprint of a sample of 113 U.S. institutions (Table 12.4), and (c) the total estimated carbon footprint of U.S. study abroad flights during the 2018–19 academic year (Table 12.2).

Conversion to:	a) 3.176 metric tonnes CO_2-eq	b) 855.5 metric tonnes CO_2-eq	c) 1,102,535 metric tonnes CO_2-eq
Greenhouse gas emissions from this number of passenger vehicles driven for one year.	0.69	186	239,779
CO_2 emissions from this number of homes energy consumption for one year	0.38	103	132,771
Greenhouse gas emissions avoided by this number of incandescent lamps switched to LEDs	120	32,424	41,787,155
Greenhouse gas emissions avoided by this number of wind turbines operating for one year	0.0007	0.178	229
Carbon sequestered by this number of tree seedlings grown for 10 years	52.5	14,146	18,230,633
Carbon sequestered by this number of acres of US forests preserved from conversion to cropland in one year	0.022	5.8	7,538

Carbon Offsetting of Study Abroad Flights

The presented data shows that air travel for study abroad has a significant carbon footprint and is a large contributor to anthropogenic climate change. We are not suggesting study abroad be stopped or significantly scaled back, yet the environmental impact of the sector has been recently called into question (Hale, 2019; Redden, 2019). If we are to consider the majority of study abroad travel worthwhile in terms of the educational, cultural, and social development of students, then the sectors, including students, programs, and institutions, need to take steps to minimize or even neutralize its environmental and climate impact.

Carbon offsets are actions that attempt to neutralize carbon emissions by supporting projects or actions that reduce or sequester emissions. The carbon footprint can be estimated using the techniques shown in this paper, but calculating our carbon reduction through offset measures is much trickier. There are many ways in which we can offset carbon emissions, but in many cases, the accounting for carbon in the offset process is much more vague and inexact.

Many airlines provide optional opportunities to offset the carbon produced, often in partnership with external organizations, with costs added to the price of the flight ticket. For example, American Airlines partners with Cool Effect (2021) to support projects including forest preservation and regeneration in Mexico, peatland restoration in Indonesia, and funding fuel-efficient cookstoves for families in Honduras. Cool Effect (2021) indicates that the cost of offsetting flights is $10.64 per metric tonne in October 2021. This suggests the average study abroad student, emitting 3.176 metric tonnes for their flights, could offset the carbon impact by donating slightly less than $34. The sector as a whole could offset all of the flights to and from study abroad sites for about $11.7 million. Note that other offset providers may value the cost of carbon offsetting differently, and often higher, with the price depending on the type of carbon offset project, the carbon standard under which it was developed, the location of the offset, and the co-benefits associated with the project.

The concept of the 'social cost of carbon' includes the economic harm associated with the impacts of climate change, expressed as the value of total future damage caused by the emission of one metric tonne of carbon. The current social cost of carbon is approximately $51 per metric tonne under the Biden administration (Chemnick, 2021; National Law Review, 2021). Using this value, the social cost of carbon emissions attributed to each student could reach over $160, and for the sector as a whole, it would approach $56.5 million.

Carbon offsetting organizations pool funds to sponsor projects, often working directly with communities to plant trees, preserve forests, lessen dependence on carbon-intensive fuels, and invest in clean energy. Gold Standard (2021) is an organization established by the WWF and other international NGOs to ensure environmental integrity and contributions to the sustainable development of offset programs.

Some study abroad providers are already working to offset the carbon footprint of their students' flights. U.K.-based FIE has been working with Climate Care for several years to offset all staff flights, and all student flights from the U.S. to their centers in London and Dublin. This initiative came directly from FIE's senior leadership and, in the past few years, has resulted in the offsetting of about 1,500 flights at an average cost of approximately $10 per return flight (M. Blakemore, personal communication, 2021). Student reaction to this initiative has been very positive.

Similarly, The Asia Institute has sponsored the planting of almost 4,000 trees in Asia through the Million Tree Project and Trees for All to partially offset the student travel carbon footprint (B. Fueling, personal communication, 2021).

On-Site Program Options for Offsetting Carbon

There is great potential for students and programs to take a more proactive role in reducing carbon footprints, as opposed to paying someone else to take care of it for them. Students directly involved in the offsetting process, when coupled with clearly defined learning outcomes, are likely to develop a more meaningful commitment to future sustainable choices . Abroad programs stand to play a major role in educating students of their carbon footprint and environmental impact and facilitating activities to help offset this carbon.

Tree Planting

Tree planting is a commonly used method of offsetting carbon. The exact number of trees needed to be planted to offset a flight is a challenge to calculate, as the amount of carbon sequestered depends on species, climate, soils, the likelihood of survival, and time period for growth. So, the question of 'how many trees do I have to plant' does not have an easy answer. Using the U.S. EPA equivalencies calculator and data in Table 12.5, it is estimated that the average students' study abroad flights could be offset by the growth over 10 years of 53 planted tree saplings. It should be noted that tree planting has significant long-term carbon storage benefits but a much reduced short-term benefit during the early growth stages. In many countries, there are environmental organizations that will work with groups to facilitate local tree plantings, such as Hometree (2021) and Crann (2021) in Ireland and Reforest'Action (2021) in France.

Wetland Restoration

Wetlands, especially peatlands with thick stores of organic material, store far more carbon per area than forests. In many countries, wetlands and peatlands have been degraded through drainage, peat extraction, or conversion to agricultural land. As the environmental benefits of wetland preservation and restoration have become more widely known, many countries have established programs to preserve existing wetlands and restore those whose environmental functions have been degraded. Activities suitable for student involvement include blocking drainage channels (raising the water level and promoting carbon storage), replanting wetland species, and monitoring projects. Again, it is difficult to calculate or estimate the carbon offset impact on a per student basis in wetland restoration projects.

Other Program Energy Reductions

Study abroad programs can also contribute to lowering the carbon footprint of study abroad through various measures. These include switching to renewable energy suppliers, reducing energy usage, avoiding non-essential flights, reducing waste, promoting recycling and reusing, using local suppliers with sustainability credentials, and providing resources on sustainability to students, housing providers, and host families. Carbon offsets or savings are difficult to quantify except in the case of measured reductions in energy usage and the use of renewable resources.

Educating Students and Promoting Less Carbon-Intensive Lifestyle Options

Educating students and involving them in lifestyle activities related to reducing their carbon and environmental footprints should be embedded within study abroad programs (Hale, 2019) (Table 12.6). One way to do this effectively is to have students conduct a carbon footprint of their U.S. lifestyle and contrast it with a footprint of their time studying abroad, with the aim of highlighting where carbon savings can be made or are being made while living abroad. Several personal carbon footprint calculators exist for this purpose, including those from the U.S. EPA (2021b), the University of California at Berkeley's Cool Climate Network (2021a), and the University

Table 12.6 Lifestyle actions that students can take in order to lessen their environmental and carbon impact while studying abroad.

Activity	Environmental impacts
Promoting reduced meat, meat-free, vegetarian, and vegan diets	Beef and pork have significantly higher carbon cost per serving than poultry or fish. Fully vegetarian or vegan diets have significantly lower carbon footprints than non-vegetarian diets
Consuming locally-sourced foods	Reduces carbon emissions from the transportation of food supplies while supporting local businesses.
Walking, cycling, and using public transportation	Avoids or reduces carbon emissions from travel while promoting exercise.
Shorter and colder showers	Promotes lower water heating and consumption demand.
Washing clothes in cold water	Reduces water heating energy consumption
Lower the thermostat and reduce air conditioning use in student housing	Reduces energy consumption
Participate in sustainable events, such as community clean-ups, recycling efforts, and composting.	Onsetting activities that may not have a carbon equivalency, but promote more environmentally sustainable communities, lifestyles and behaviours.
Using more environmentally-responsible modes of travel	Train and bus travel, particularly electric or hybrid vehicles, have lower carbon footprints than air travel, and should be promoted where feasible. Direct flights have lower carbon footprints than the same destination with connecting flights.

of Washington's International Student Carbon Footprint Challenge (2021). Many of these personal actions have a much more immediate impact on carbon footprints than the longer-term impacts of tree planting and wetland restoration. Embedding a culture of sustainability in a study abroad program will hopefully inspire students to continue with these measures upon their return home.

Carbon Onsetting

Carbon onsetting refers to the recognition that fossil fuel consumption has positive aspects, such as facilitating educational travel, but we cannot always offset the exact amount of carbon to account for our actions, nor should we limit our actions solely to exact offsetting. Instead, we can fund and support meaningful projects, at home and abroad, that encourage sustainable lifestyles and communities, without the need for accounting for an exact carbon equivalence. Examples of carbon onsetting projects relevant to study abroad include community clean-ups, the development of community organic food production, the preservation of at-risk lands, and projects related to the more sustainable use of resources. As an example, Pacific Lutheran University and its students work with Earth Deeds to reduce study abroad flight impacts through investment in sustainable projects both on campus and abroad (Greenberg and Fang, 2015).

Study Abroad and Sustainable Education for Students

Study abroad, while widely recognized as a valuable academic, cultural, and developmental activity for students, also represents a unique opportunity for educating students on their carbon footprint and sustainable actions in general and challenging them to take action. All study abroad programs hold orientation sessions, at which sustainability and carbon footprints should be discussed, along with options for carbon offsetting and onsetting. Collaboration between international offices and campus sustainability offices could be used to develop programs for students to learn more about study abroad, lifestyle carbon impacts, and options for reducing their footprints. Study abroad programs on-site also hold a significant amount of oversight and regular contact with their student groups, providing a perfect opportunity for promoting sustainability and reduced carbon lifestyles.

Study abroad can be an opportunity not just for intercultural learning but also for environmental learning and the development of eco-learning skill sets that can have long-lasting impacts on a students' environmental behavior. Lessons and best practices learned abroad can hopefully be brought back home for continued commitments to environmental and climate action. Instead of viewing study abroad travel as a negative, we have an opportunity to use the experience as one to teach environmental and sustainability issues for more than just the time abroad but to also instill the principles of lifelong change.

Conclusions

U.S. study abroad is a carbon-intensive endeavor as overseas travel by airplane is often required for participation. Estimates from this chapter indicate that U.S. students travel more than 5.5 billion kilometers annually just to and from their study abroad site. This is estimated to represent a total carbon footprint of over 1.1 megatonnes of CO_2-eq from the more than 347,000 students who studied abroad in the 2018–19 academic year, or an average of 3.176 metric tonnes of CO_2-eq per student. These estimates do not include any additional flights students may take while on the program, which, at least in Europe, are thought to be a significant addition to the overall student carbon footprint during study abroad. At the institutional level, study abroad flight carbon is estimated to account for a median of 3.1% of a U.S. institution's whole-campus carbon footprint. Based on the bulk data of the low end of the true carbon footprint of study abroad flights.

Students often study abroad in countries with lower per capita carbon emissions than the U.S., and thus being in-country for a period of time and living a local lifestyle can serve to offset some of the carbon emitted during travel. However, best practice suggests that it would be unwise for students, institutions, and programs to rely on such an 'offset' and that other measures should be employed to provide offsets to lessen the environmental impact of study abroad flight carbon emissions. Carbon offsetting and onsetting options include tree planting, wetland restoration, lifestyle adjustments including food consumption and travel habits, and the funding of projects intended to compensate for the carbon emissions and promote sustainable lifestyles. The study abroad experience represents an ideal opportunity for instilling sustainability education, the development of eco-learning skill sets, reduced carbon lifestyles, and environmental action within students.

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References

Atmosfair, 2016. Atmosfair Flight Emissions Calculator Documentation of the Method and Data, https://www.atmosfair.de/wp-content/uploads/atmosfair-flight-emissions-calculator-englisch-1.pdf Calculator available at https://www.atmosfair.de/en/offset/flight/

Chemnick, J, 2021. Cost of carbon pollution pegged at $51 per tonne. Scientific American, March 1, 2021, https://www.scientificamerican.com/article/cost-of-carbon-pollution-pegged-at-51-a-ton/

Cool Climate Network, 2021. Personal Carbon Footprint Calculator. https://coolclimate.berkeley.edu/calculator

Cool Effect, 2021. Welcome to Carbon Done Correctly. https://www.cooleffect.org/

Cox, B., and Althaus, H., 2019. How to include non-CO_2 climate change contributions of air travel at ETH Zurich Bern. Mobility Platform of ETH Zurich, DOI:10.13140/RG.2.2.30222.10565, https://ethz.ch/content/dam/ethz/associates/services/organisation/Schulleitung/mobilitaetsplattform/ETH%20Zurich%20flight%20reduction_calculation%20of%20non-CO2%20contribution_final.pdf

Crann, 2021. Trees for Ireland. https://crann.ie/

Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E., Solazzo, E., Monforti-Ferrario, F., Olivier, J.G.J., Vignati, E., Fossil CO_2 emissions of all world countries - 2020 Report, EUR 30358 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-21515-8, doi:10.2760/143674, JRC121460.

de Wit, H, and Altbach, P.G., 2020. Time to cut international education's carbon footprint. University World News, January 11, 2020. https://www.universityworldnews.com/post.php?story=20200108084344396

Environmental Protection Agency, 2021a. Greenhouse Gas Equivalencies Calculator. U.S. EPA, https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Environmental Protection Agency, 2021b. Carbon Footprint Calculator. U.S. EPA, available from https://www3.epa.gov/carbon-footprint-calculator/

Forum on Education Abroad, 2021. Advancing the UN Sustainable Development Goals through Education Abroad doi.org/10.36366/G.978-1-952376-09-2. Available from https://forumea.org/resources/guidelines/advancing-the-un-sdgs/

Franzen, A., and Mader, S. 2018. Consumption-based versus production-based accounting of CO_2 emissions: Is there evidence for carbon leakage? Environmental Science & Policy, Volume 84, June 2018, Pages 34–40.

Frömming, C., Ponater, M., Dahlmann, K., Grewe, V., Lee, D.S., and Sausen, R., 2012. Aviation-induced radiative forcing and surface temperature change in dependency of the emission altitude. Journal of Geophysical Research, 117, D19104, doi:10.1029/2012JD018204.

Gold Standard, 2021. A Higher Standard for a Climate Secure and Sustainable World. Retrieved from https://www.goldstandard.org/

Graver, B, Zhang, K, and Rutherford, D., 2019. CO_2 emissions from commercial aviation, 2018. International Council on Clean Transportation Working Paper 2019-16. Retrieved from https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf

Greenberg, D, and Fang, C.C., 2015. The Myth of Climate Neutrality: Carbon Onsetting as an Alternative to Carbon Offsetting. Sustainability: The Journal of Record, Vol. 8(2), DOI: 10.1089/sus.2015.0017

Guardian, 2008. Carbon Copies? Retrieved from https://www.theguardian.com/environment/2008/feb/19/carbon.web

Hale, B.W., 2019. Wisdom for traveling far: Making educational travel sustainable. Sustainability, vol. 11, 3048; doi:10.3390/su11113048

Hometree, 2021. Hometree. Retrieved from https://www.hometree.ie/

International Civil Aviation Organization (ICAO), 2021. ICAO Carbon Emissions Calculator. Retrieved from https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx

Institute of International Education, 2021. Open Doors. Retrieved from https://www.iie.org/Research-and-Insights/Open-Doors

International Student Carbon Footprint Challenge, 2021. University of Washington. Retrieved from https://depts.washington.edu/i2sea/iscfc/calculate.php

IPCC (2007) The IPCC Fourth Assessment Report. Cambridge University Press., Cambridge.

Jungbluth, N, and Meili, C., 2019. Recommendations for calculation of the global warming potential of aviation including the radiative forcing index. The International Journal of Life Cycle Assessment, vol. 24, p. 404–411. DOI:10.1007/s11367-018-1556-3

Lee, D.S., Fahey, D.W., Skowron, A., Allen, M.R., Burkhardt, U., Chen, Q., Doherty, S.J., Freeman, S., Forster, S., Fulgestvedt, J., Gettelman, A., DeLeon, R.R., Lim, L.L., Lund, T., Millar, R.J., Owen, B., Penner, J.E., Pitari, G., Prather, M.J., Sausen, R., and Wilcox, J., 2021. The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmospheric Environment*, v. 244, 117834.

MyClimate, 2019. Calculator and Calculation Principles. Retrieved from https://co2.myclimate.org/en/flight_calculators/new

Padgett, J.P., Steinemann, A., Clarke, J.H., and Vandenbergh, M.P., 2008. A comparison of carbon calculators. Environmental Impact Assessment Review, 28, p. 106–115.

Redden, E., 2019. International educators begin to confront the climate crisis. *Inside Higher Ed.*, December 19, 2019. Retrieved from https://www.insidehighered.com/news/2019/12/19/international-educators-begin-confront-climate-crisis

Reforest'Action, 2021. I Plant My Forest. Retrieved from https://www.reforestaction.com/en

Shields, R., 2019. The sustainability of international higher education: Student mobility and global climate change. *Journal of Cleaner Production*, v. 217, p. 594–602.

World Bank, 2019. CO_2 Emissions (metric tonnes per capita). Retrieved from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2014&start=1960&view=chart