Identifying Sustainable Development Goal Research Trends and Recommendations for Future Research

By

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2023

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Abstract

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The Sustainable Development Goals (SDGs) are a set of 17 benchmarks developed by the United Nations in 2015. The intent of the SDG framework is to bring sustainable prosperity to all people on Earth by the year 2030. As of June 2022, we are halfway through the period the SDG framework was designed to study and there have been countless papers published documenting the progress of these goals and their interactions. We performed a systematic review of 690 papers that document one or more SDG and analyzed research patterns and trends within this corpus, including: frequency of SDGs studied across time, geographic scale, SDG interactions, interactions interpreted by researchers as important or significant, and commonly used keywords corresponding with SDG research. In addition to analyzing overall SDG trends, our team aims to further analyze the SDG 2 within the context of the food-energy-water (FEW) nexus, which highlights the authoring team's areas of expertise and interest. The emphasis on the FEW nexus may serve as a demonstration of how trends in SDG research can shed light on the interdisciplinary relationships across sectors. Our team acknowledges that we are not experts on all 17 of the SDG realms and encourage other authors to use our open-source data to analyze other goals in a deeper way than we are capable.

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Finally, I would like to thank all who have helped me acknowledge sustainability's importance not only in a tangible sense but also in a personal sense. Very thankful to the friends who hold me accountable to the principles of sustainability not only in my consuming habits but also with my time and energy.

"Six years you shall sow your land and gather in its produce, but the seventh year you shall let it rest and lie fallow, that the poor of your people may eat; and what they leave, the beasts of the field may eat. In like manner you shall do with your vineyard and your olive grove."

- Exodus 23:11

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Glossary

Influencing Interactions- Indicates that within an interaction, that the goal of focus' status impacts another goal's status.
Influenced Interactions- Indicates that another goal's status is impacting the goal of focus.
Interaction measure of how one goal's progress impacts another goal.
Synergy- positive interaction; when one goal's advancement positively affects another goal's status
Tradeoff- negative interaction; when one goal's advancement negatively affects another goal's status
Significant - subjective measure of an interaction's value, denoted by paper studied
Food- energy- water (FEW) nexus commonly referenced group within the SDGs consisting of SDGs 2, 6, and 7.

1. Introduction

1.1 Sustainable Development Goal Overview

On September 27th, 2015, members of the United Nations were assembled to vote on the post-Millennium Development period framework for measuring sustainability. The passing framework resulted in the Sustainable Development Goals (SDG) that were presented at the UN Summit on January 1, 2016. There are 17 SDGs included in this framework that are designed to build from the 8 Millennium Development Goals (MDGs) that measured sustainability for the period 2000- 2015. Within the SDG framework, 169 targets along with 232 indicators were designed to monitor the 17 goals (full list of all indicators, targets, and goals located in Appendix A as Table 1A). The SDGs are designed to measure sustainability from 2015 through 2030. The SDGs expanded upon the MDGs by exploring and combatting the root reasons behind poverty as well as including a stronger emphasis on climate change (United Nations, n.d.; Enel Américas, 2016). Like the MDGs, the SDG framework is not legally binding; however, each participating country is expected to develop a national framework to implement and monitor these goals within the 15-year period (United Nations, n.d). Therefore, each countries' overall SDG framework success is contingent on that countries' ability to implement effective policies, actions, and financing strategies for the SDGs.

1.2 Existing SDG Research

There are many reports released by the United Nations and other large organizations concerning capturing as much information as possible concerning SDG progress on a global scale such as the Annual Sustainable Development Goal Report United Nations published by the International Council for Science (ICSU) or 'A Guide to SDG Interactions: from Science to Implementation' distributed in 2017. There are also many comprehensive databases that track data across 200+ countries as reported over time such as the UN Statistics Division's SDG Indicators Global Database, World Bank's World Development Indicators, and the FAO SDG Data Portal provided by the UNFAO Statistics Department (UN Statistical Commission, 2022; World Bank Group, 2022; UNFAO Statistics Department, 2022).

The SDGs were designed to be reported on a national basis through Voluntary National Reviews (VNR) that are submitted to the UN through the High- Level Political Forum (HLPF) (Allen, Metternicht, Wiedmann, 2021). Not all global nations are part of the UN and even if they are, they may lack the economic or structural means to thoroughly track 232 SDG indicators. Meaning that, even the most comprehensive reports will not contain a complete global picture of the SDG status. Additionally, VNRs do not take into consideration interaction effects between the SDGs (Allen, Metternicht, Wiedmann, 2021). Additionally, there remain 80 indicators that were labeled grey by the UN Statistical commission in 2016 indicating that "more in-depth discussion was needed" before coming to a universal measurement agreement (UN Statistical Commission, 2016; Georgeson & Maslin, 2018). As of 2018, these grey indicator measurement systems had yet to be clarified (Georgeson & Maslin, 2018).

Most existing resources focus on the national level of documenting SDGs and negate indicators that still have vague monitoring credentials provided by the UN. Academic based studies play a large role in attempting to fill these large research gaps. As of December 27th, 2022, there are 11,804 publications with "SDG" or "Sustainable Development Goal" in the keywords, abstract, and title (SCOPUS, 2022). Additionally, around half of these papers are labeled as Open Access (n= 6,497 as of December 27th, 2022) (SCOPUS, 2022). There are many strategies are used to bridge the research gaps. Many studies attempt to measure SDG indicators using remote sensing and modelling techniques to fill geographic gaps or propose indicator measurement methodologies (Mondal, McDermid, Qadir, 2020; Reith et. al, 2021; Kumar et.al, 2018; Mansell, Philbin, Broyd, 2020; Wang et.al, 2020). Some studies take the more qualitative approach of interviewing a group of stakeholders or experts to gain insight into SDG indicator status or measurement techniques (Ojutkangas, Rossi & Matinmikko-Blue, 2022; Van Soest et. Al, 2019). Others connect SDG targets and indicators to company or sectoral efforts and quantify how actions contribute to the SDG agenda (Nitsenko et.al, 2017; Lopez, 2020). There is also a large body of work that provides evidence or expert opinion-based critiques of the SDG framework and/or implementation (Prince, 2019; Pisupati, 2015; Munro, van der Horst, Healy, 2017). There are also studies that have tracked interrelations between SDGs based on a

variety of available data sources including large data tracking databases (Requejo-Castro, Giné-Garriga, Pérez-Foguet, A.,2020; Anderson et. Al., Swain, Ranganathan, 2021; Costa, Cancela, Reis, J., 2021, Ospina, Castañeda, Guerrero, 2020) model projection (Shaw, Kennedy, Dorea, 2021; Macmillan,2020), or literature reviews (Hoelt., Brandtweiner, Bates, Berger, 2020; Cernev, Fenner, 2020; Zhao, et. Al, 2021).

1.3 Research Justification and Objectives

It is important to evaluate SDG research trends to determine how these papers can address the overall critiques of the SDG agenda. Additionally, the SDGs offer a glimpse into how 17 sectors are being viewed and treated by researchers on a global scale. Evaluating how this research is being studied can shed additional light on how interactions between sectors affect sustainable progress overall and which sectors are potentially being neglected. Our study aims to quantify trends through the evaluation of SDG research papers using the search engine SCOPUS. Overall SDG research trends will be evaluated in addition to SDG interaction research papers. Due to our team's area of expertise, additional attention with be paid to SDG 2 (Zero Hunger) and its role in the Food, Water, and Energy Nexus.

1.4 Food, Water, Energy Nexus and SDGs Relationship Reviewed

The food, water, energy nexus (FEW) nexus, sometimes referred to as water, energy, food or WEF nexus, refers to evaluating the water, energy, and food resource pillars as interconnected and dependent on one another. The FEW nexus to prominence in 2011 after being mentioned and discussed in several high-profile speeches, conferences, and research articles (Simpson & Jewitt, 2019). The food, water, energy nexus is a resource-oriented hierarchy (Higgins, Abou Najm, 2020). Therefore, there are different 'stages' that need to be considered when we consider how they relate to meeting the population's water, energy, and food needs (see Figure 1 for example of stage approach applied to the pillar of food resources.) Stage 0 references the chemical components and thermodynamic state needed to utilize a resource. Stage 1 refers to the distribution of the water, energy, and land resources in space and time as well as natural events that could impact these factors. Stage 2 refers to the products that are made ready for anthropogenic consumption through work on

resources mentioned in Stage 1. Stage 3 considers how products of an operation can be distributed to meet a population's needs (Higgins, Abou Najm, 2020).

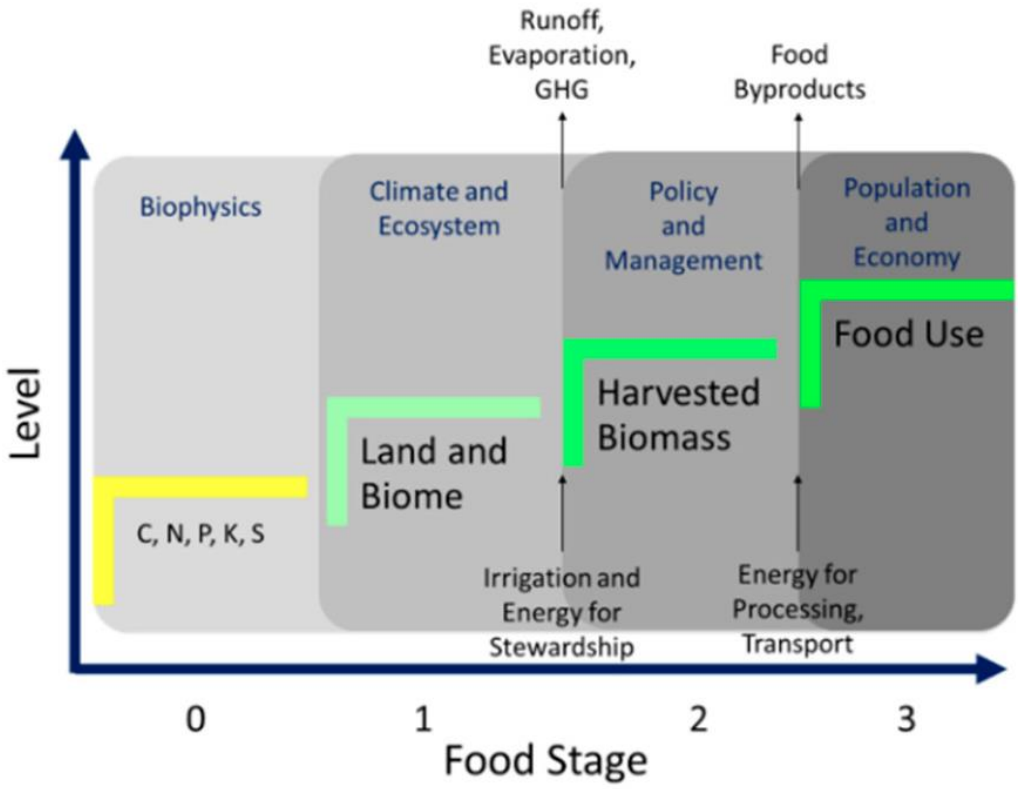

Figure 1 adapted from Figure 1a in Higgins, Abou Najm that demonstrates the stage framework for the food pillar of the FEW Nexus (2020).

The FEW nexus approach is often used when evaluating the impact that SDG 2 (zero hunger), SDG 6 (clean water and sanitation), and SDG 7 (clean energy) within the SDG framework. There is a growing body of research analyzing the role of the FEW nexus and SDG implementation in varying contexts (Malagó et. Al, 2021; Wang, 2021; Rasul, 2016; Wang, Fu, & Liu, 2021; Libanio, 2022).

2. Methodology

The main objective of this study is reporting which SDGs were the most studied and summarizing SDG interaction results. Other trends within the SDG literature database such as the larger geographic scale SDGs and year published were also documented and analyzed. This information can help identify SDG trends across time as well as identify gaps in knowledge particularly for the location and spatial factors. The third objective is that with the collection of studies separated by goals we can conduct deeper analysis on goals within the FEW Nexus. SDG 2 will be further evaluated through a FEW nexus lens in order to explore at what scientific level current SDG 2 focuses on.

2.1 Inclusion Criteria

A systematic literature review was performed using the search engine SCOPUS in which 2,601 papers that referenced the SDGs in the Title AND Keywords were downloaded (See exact search criteria used for search refer to Table 18A). The main objective of this body of research is to identify research trends from articles that study the Sustainable Development Goals. To get the clearest picture of research trends, papers from the initial SCOPUS search were subjected to a thorough screening to ensure that the research topic directly concerns the SDGs. In the scope of this study, we prioritized this process in this research because as previously stated, even if a paper lists SDGs in its title or keywords that does not necessarily indicate that the research conducted correlates to SDG status or implementation.

For a paper to be included in the ultimate dataset it needed to be established that SDGs were the main focus of that study. To confirm that SDGs were a main focus of a given study, two aspects of the paper were analyzed: the frequency and location of the word “SDG” throughout a paper and degree of original SDG analysis that the paper exhibited. All papers included in the final dataset mentioned SDGs in sections other than the introduction and/ or conclusion OR they included an in-depth explanation of how SDGs were directly related to the content analyzed (e.g. linking a core measurement to a specific SDG indicator or target). Additionally, all included studies have to contain

original analysis concerning the SDGs. Original analysis is defined in this context as generating new knowledge concerning a SDGs status or usage (e.g. measuring an indicator in a new context, evaluating a relationship between a study topic and SDGs, exploring an indicator's usage in a given area, etc.). The criteria of original analysis was included to ensure that data cited from previous studies was not considered new data. Not including the original analysis criteria would risk of recording a study's SDGs of study twice or unintentionally plagiarizing an unincluded study.

See Figure 2 for additional details on the inclusion and exclusion process including a breakdown of each step in this process and numbers of papers removed.

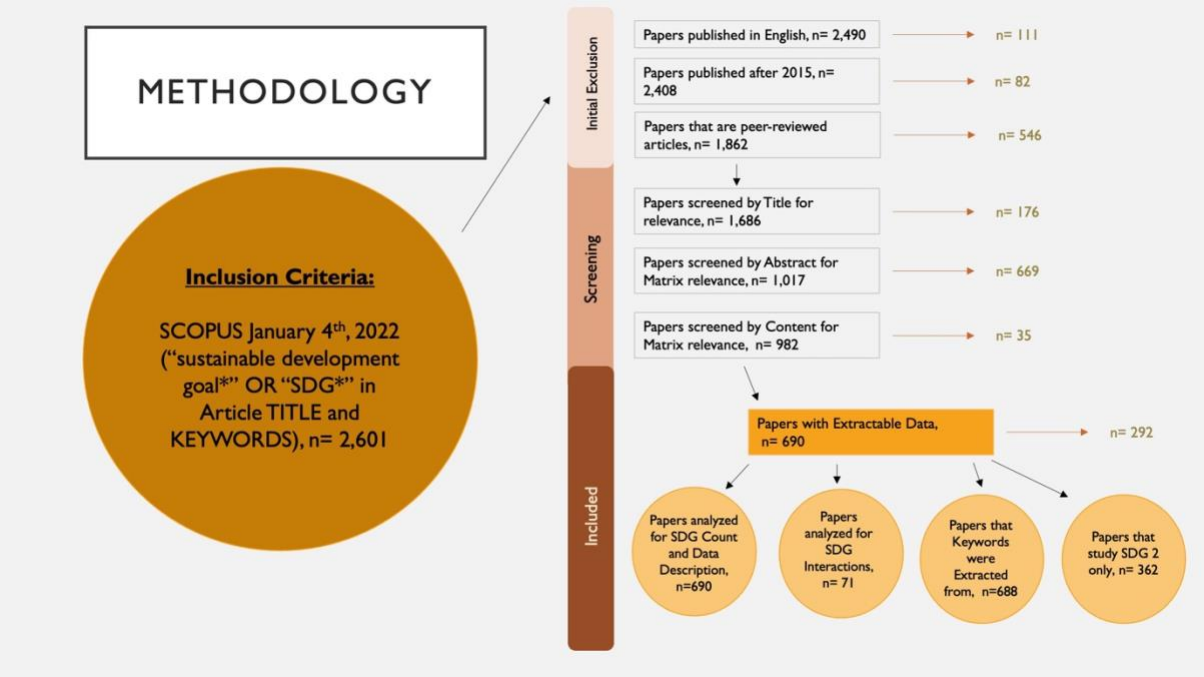

Figure 2 explains the inclusion and exclusion criteria used for this research. The chart shows the various stages of this process and notes how many papers were removed at each stage. The chart also breaks down how many papers are analyzed for each of the trends studied. Table 18A in appendix shows the exact search criteria used in SCOPUS to get the initial group of papers.

This network analysis resulted in a full dataset of 690 relevant studies that was evaluated from several perspectives to quantify different research trends. The datasets that are independently analyzed within the full dataset (n=690) are: papers that evaluate interactions between the SDGs (n=71) and papers that study SDG 2 specifically (n= 362). The following sections will break down the methodologies and explain dataset differences associated with each of the analysis'.

2.2- Data Analysis Methodologies

2.2.1- SDG Frequency Methodology

The SDG frequency analysis was conducted to determine the extent that each SDG was studied within the entire dataset (n=690). All paper titles were listed in an excel sheet along with adjacent columns that corresponded with all 17 SDGs. If an SDG was adequately studied in a paper, then that column was marked with a 1 while unstudied SDGs were marked with 0s. It should be noted that sometimes papers researched SDGs to differing degrees and when this was the case, these two criteria pieces discussed in section 2.1 were used to confirm if a SDG should be marked as studied or not. At the end of this assessment, all 690 paper's SDG columns were summed to produce the overall SDG Frequencies denoted in Results section 3.1. All statistical analysis was conducted using R and excel software. SDG frequency significance was determined using a chi-squared goodness of fit test with an alpha value of 0.05 and an assumed Poisson distribution setting. The expected probability of each goal was 1/17, or 5.88% in order to accept or reject the null hypothesis that each SDG is studied to the same extent.

Further analysis was conducted in this category concerning the distribution of SDGs in the case that papers that evaluate all 17 SDGs (n=255) are excluded (n= 435). One additional subset of data in this section focuses on only studies where one SDG was analyzed (n=249). Significance for the single SDG subset of data were determined using the same methodology mentioned previously in this section.

A correlation matrix was also calculated using R software on the subset of data where all papers are included except for papers analyzing all 17 SDGs. The Pearson's coefficient (r) calculation was conducted on each of the SDG pair's frequencies to determine the linear relationship between the two SDGs. The following equation is the Pearson's equation that the binary data was subjected in order to yield the results in Figure 5 and Table 4A:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

r = correlation (Pearson's) coefficient

x_i = values of the x-variable in a sample

$\bar{x}$ = mean of the values of the x-variable

y_i = values of the y-variable in a sample

$\bar{y}$ = mean of the values of the y-variable

2.2.2- SDG Temporal Scale Methodology

The analysis of the temporal patterns evaluated all studies in the full dataset with the exception of papers published in 2022 (n= 12). At the time of download, Jan 4th, 2022, papers published in 2022 could not be considered a full year of data and therefor, this data was excluded. Analysis of this data began by determining the number of papers published within each year in the time period analyzed (2015-2021). Then, the SDGs studied in each of these papers were summed to get a values that demonstrate how frequently a given SDG was studied within a given year. This was plotted for each year in the range 2015- 2021 and the resulting table was used to create Figure 6 in excel. One should note that because most of the papers in this dataset study more than one SDG, that the total number of SDGs studied will not be equal to 678. No significance was calculated for this section.

2.2.3- SDG Spatial Scale Methodology

One aspect of interest for this research is the geographic scale that each paper was conducted at. To explore this aspect, four scale categories were developed and then assigned to each of the 690 papers analyzed during the data collection phase. The geographic study categories were defined as:

- Local- Evaluates SDG status of an area smaller than a country. (e.g. city, region within a country, etc.). If exclusion criteria was included within a countries' borders (e.g. only coastal cities analyzed in a country, then study was considered local).
- National- Evaluates SDG status of the entirety of a sovereign nation.
- MultiCountry- Evaluates SDG status of two or more countries and takes into consideration at least one excluding factor. It should be noted that MultiCountry is the most diverse category in terms of geographic scale. This category ranges from two countries studied, even if it happens to be a local area that straddles an international border, to large international regions (e.g. the EU, African countries, low-income countries, etc.)
- Global- Evaluates SDG status using the largest available dataset. If study has no specified scope it is considered global.

Following the full assessment of 690 papers, each paper was sorted by geographic category and summed using Microsoft excel to get total geographic category totals. The papers were further sorted by SDG studied within each geographic category to produce Figure 8. Significance for the spatial distribution was calculated using the same chi- square good ness of fit methodology discussed in section 2.2.1. The expected probability for the chi-square calculation was set to ¼ or 25% per category in order to accept or reject the null hypothesis that SDGs are studied equally at each geographic scale. Geographic scale of the studies was also plotted across time using excel (Figure 9).

2.2.4- Keyword Extraction

The total number of papers is slightly lower in the section (n=688) because some papers did not include keywords or a clearly specified list of keywords. The data collection for this section included documenting every keyword on the SCOPUS website for an individual paper and listing each word in a separate cell adjacent to the paper's title. The complete list of keywords was analyzed further in excel and used to produce a frequency of each keyword's appearance in the SDG dataset (first 25

words documented in Table 2). Figure 10 (word cloud) was created by inputting data in R and using wordcloud package to document all unique words.

2.2.5- Interactions Between SDGs

During the abstract separating phase of this study, papers that studied relationships between SDGs were marked. This subset of data totaled 71 papers and these papers were separately analyzed. These papers underwent the same inclusion and exclusion criteria mentioned in section 2.2.1. An additional inclusion criterion for this subset of papers was containing evidence-based results concerning the relationship of at least two SDGs. Data for this section were recorded using binary 0 and 1 based system used in section 2.2.1 but within a grid of influenced and influencing goals. It was noted in the data collection process which of the goals was the influencing and influenced goals. If there was no specification of this in a given study, then it was assumed that the author was referring to a two-way impact and this was documented by a "1" in the influenced and influencing goal spots. Two sets of data recordings were taken for each of the 71 papers: the interactions that were studied and the interactions that were labelled as "significant" by the study's respective author. It should be acknowledged that the term 'significant' within this section was left up to the discretion of the authors of each paper; therefore, significant in this section is a subjective measure.

The excel pivot table function was used to add each of the corresponding interactions after data collection was complete. This resulted in a 17 by 17 matrix where the top x-axis (labeled with SDGs 1-17) represented the influencing goals while the y axis represented the influenced goals. There were two matrices developed for this dataset (n=71). One matrix contained SDG studied interaction summed results and the other contained the labeled significant interaction summed results (Tables 9A and 10A, respectively in appendix). These matrices were imported into R software and used to generate Figures 11 and 12. Note that the aforementioned figures do not differentiate between influencing and influenced goals and Tables 9A and 10A need to be consulted for that data. Due to the complexity of this dataset and the subjectively of significance in this context, significance was not

calculated for the interaction data subset. The widely used methodology for analyzing the magnitude presented in Nilsson et. Al's work was deemed inappropriate in this study because of the wide variety of data types used and the subjectivity of significance within the interaction analysis (2016).

2.2.5a- Synergies

Directionality or the positive or negative nature of an interaction (see glossary) was not documented among all of the 71 interaction papers. As a result, there are less papers that explore positive relationships (n=57). Like the previous section, both studied synergies and those labelled significant by researchers were documented in put into result matrices. Corresponding figures (Figures 12 and 13) for synergies were generated using the same methodology described in section 2.2.4. Tables 11A and 12 A in the appendix contain the corresponding information to Figures 13 and 14.

2.2.5b- Tradeoffs

There are less papers that explore negative relationships (n=57) similar to the synergy section. It should be noted; however, that some of the papers in the tradeoff subsection of data differ from the synergy papers. This is because some papers only analyze positive relationships with no mention of negative interactions or vice versa. Like the previous section, both studied synergies and those labelled significant by researchers were documented in put into result matrices. Corresponding figures (Figures 14 and 15) for tradeoffs were generated using the same methodology described in section 2.2.4. Tables 13A and 14A contain the corresponding data to Figures 15 and 16.

2.2.6 The FEW Nexus

The FEW Nexus additional was conducted by taking a subset of data Tables 12A and 14A to create a small matrices between SDGs 2, 6, and 7 only. These matrices were then run through R software to create Figures 16 and 17 using the same methodology described in section 2.2.5. Note that interactions are used as opposed to paper counts because it would not be accurate to label each n as an independent paper in this analysis. The same 57 studies are consulted for this data but papers can be

cited more than once due to more than one SDG pair being examined in each paper or more than one datasets can be pulled from a single paper if a different methodology is deployed within one paper. The smaller matrices used in this section are listed in the appendix as Tables 15A and 16A.

2.2.7- SDG 2 Extended Analysis

The extended analysis of SDG 2 involves building off the FEW stage framework system proposed in Higgin's and Abou Najm's work (2020). Our research team identified 3-4 words that correlated with each stage in the food pillar category. The words and that were selected for each stage are listed in Table 1. These words were searched using the control F function and counted in each of the SDG 2 papers (n=362). Stage words that were present in a paper but used in references or in-text citations were not counted in this study. It should also be noted that one of the papers that studied SDG 2 was taken down after the initial SDG frequency analysis and could not be used for this portion of the study resulting in a lower all 17 SDGs paper number (254 versus 255). Word totals were summed after all papers had been searched. Data was then imported into R and histograms of each word were created. SDG 2 papers were also separated into two sub-categories to be separately analyzed. A set of histograms were created for papers that evaluated all 17 SDGs within the SDG 2 dataset (n= 254) as well as the remaining papers in this dataset that studied less than 17 SDGs (n= 108). Pearson's coefficient equation was also used on this dataset following the methodology listed in section 2.2.1 to construct correlation matrices. The correlation matrices were constructed using R software and excel to create Figures 23 and Table A17.

Table 1 lists the 15 words that were searched for in each paper. This paper also breaks down the words by associated stage in accordance with Higgins, Majdi's FEW framework system (2020).

Stage 0	Organic Matter
	Carbon
	Nitrogen
	Soil
Stage 1	Land
	Energy
	Water
	Biome
Stage 2	Food

	Nutrition
	Crop
Stage 3	Biomass
	Yield
	Agriculture
	Structure

3. Results

3.1. SDG Frequency Analysis

The SDG Frequency analysis ranks the SDGs in order of most to least studied and derives significance from the frequency distribution. The most studied SDG in the full dataset (n=690) is SDG 6 (water and sanitation, n= 402), closely followed by SDG 3 (health and well-being, n=401) and SDG 11 (sustainable cities and communities, n= 385). The least studied goals are : 1) SDG 17 (partnership for the goals, n= 300), SDG 10 (reduced inequalities, n=306), and SDGs 5 and 16 (gender equality and peace, justice, and strong institutions, n= 314 for both respectfully). The ranking for each SDG and other information can be found in Figure 3 and Table 2A. It is important to note that within the full dataset, that 255 papers analyze all 17 SDGs and beyond that, 186 papers research more than one SDG. Therefore, counts were conducted of SDG frequency in each of these subcategories.

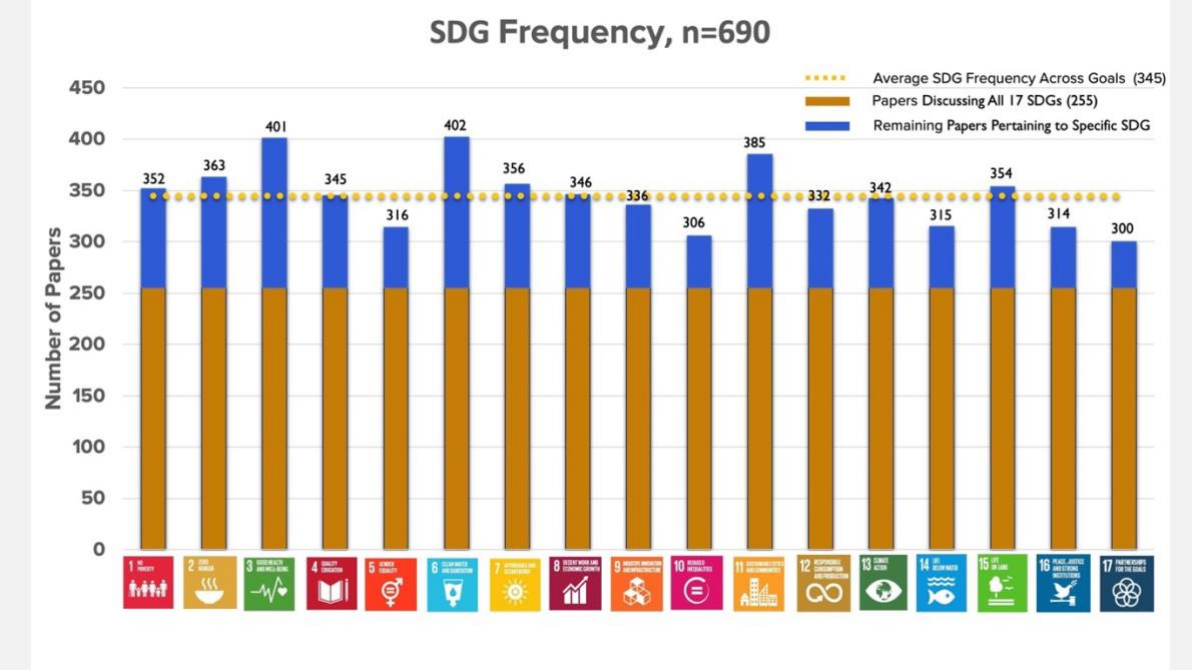

Figure 3 shows the distribution of SDGs studied across the 690 studied that were analyzed. The most studied goals are: 1) SDG 6 (n=402 papers), SDG 3 (n=401), and SDG 11 (n= 385) and the least studied goals are: 1) SDG 17 (n= 300), SDG 10 (n=306), and SDGs 5 and 16 (n= 314 for both respectfully). However, it is important to note that many of these papers (255) analyzed all 17 SDGs as denoted by the brown portion of each column. The data used to construct this Figure can be found in Table 2A.

A noticeable difference to SDG rank is detected when analyzing the 36% of papers that focus on one SDG (n= 249). The top three SDGs in this subcategory are SDG 6 (n=43), SDG 11 (n= 41), and SDG

3 (n= 37). Given that SDG 3 is close to the top in the overall frequency analysis (n=401 compared to n=402 for top studied SDG 6), it is surprising that SDG 3 is lower on the single SDG studied ranking. This allows us to conclude that SDG 3 (well-being) is often being studied with other goals. The bottom three SDGs for single study SDG papers also differ from the overall frequency analysis. The lowest studied SDG in this subset is SDG 10 (reduced inequalities, n=1) followed by SDG 5 (gender equality, n= 4), and SDGs 2, 9, and 13 (n= 6 for each, respectively). The significance of the overall SDG distribution in the one SDG subset of data is very significant with a p-value equal to $2.2e^{-16}$. The total SDG frequency of single SDG papers can be found in Figure 4 or Table 3A.

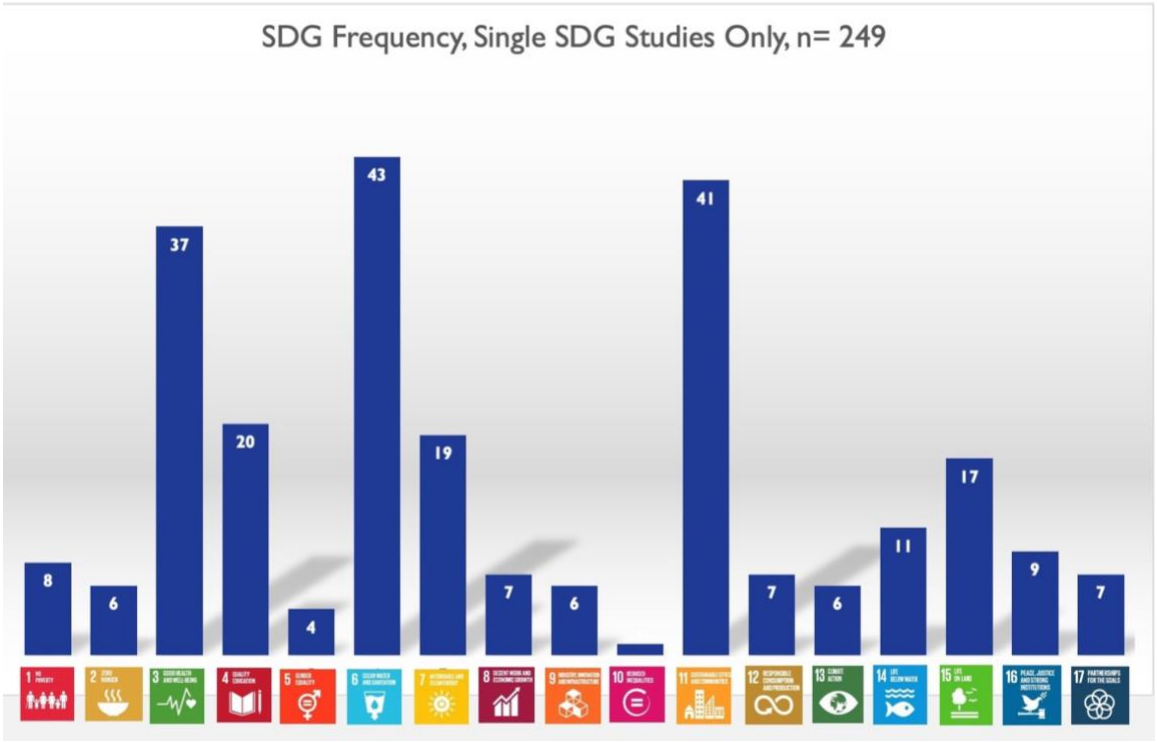

Figure 4 shows the SDG frequency across the 249 papers that analyzed only one SDG. The top SDG evaluated in this subset of papers is still SDG 6 followed by SDG 11 (n= 43 and 41, respectively). The data used to construct this Figure is located can be found in Table 3A.

Figure 5 demonstrates the results of a correlation matrix that mapped how the studying of one SDGs in a paper impacted the probability that another SDG would be mentioned. It is important to note that this figure does not reflect the total number of appearances. The results of the correlation matrix showed that the pair of SDGs with the highest correlation rate is SDG 1 (no poverty) and SDG 2 (zero hunger), (n=0.61). The next highest correlation between SDG pairs is between SDG 8 (decent work and economic growth) and SDG 9 (industry, innovation, and infrastructure) (n= 0.60) followed by SDG 5 (gender equality) and SDG 10 (reduced inequalities). The associated correlation matrix is in

the Appendix as Table 4A. Refer to Figure 5 or Table 4A for more information for correlation rates between specific SDG pairs.

Figure 5 is a graphical display of the correlation matrix (Table 4A) that maps the covariance ratees among SDG pairs in the full dataset excluding the All 17 SDGs papers (n=435). This chart links words that are more likely to appear given the presence of the connecting word. Equation for Line Width= line width and transparency is determined by corresponding decimal in correlation matrix. This chart does not reflect the number of times SDG is studied.

3.2 SDG Research Temporal Scale Analysis

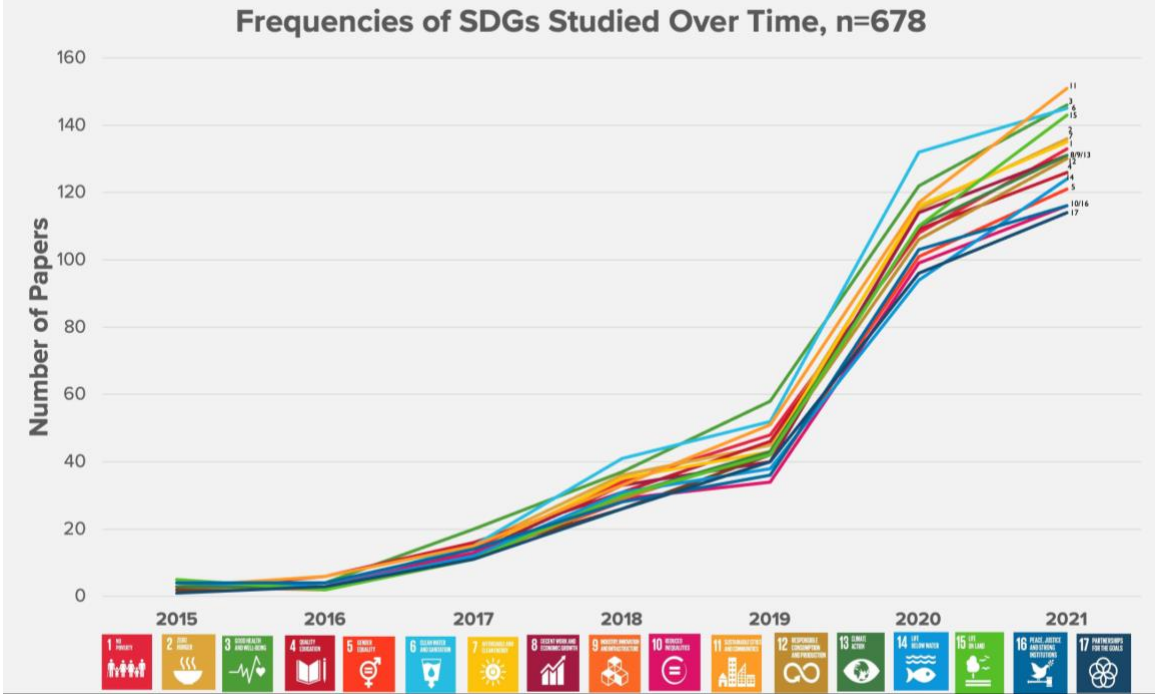

Figure 6 shows the distribution of SDGs studied during the period 2015- 2021. Note that papers published in 2022 have been excluded from this chart because at the time of download, 2022 did not include a full year's worth of data. Table 5A contains numerical data that was used to create Figure 6.

The temporal aspect of this research was analyzed using the year that studied published. The average growth rate of SDG papers published between 2015 and 2021 is +84.31%/ year, clearly indicating an upwards trend across the time range. This rate seems to apply relatively evenly across the SDGs. The top 3 overall studied SDGs (6, 3, and 11, in order of most to least studied) are the top three SDGs for three years (2019- 2021) although they switch in order throughout this time period. Each individual SDG has its own trajectory throughout the years studied as shown in Figure 7.

SDG	# of Papers Published in 2016	# of Papers Published in 2017	# of Papers Published in 2018	# of Papers Published in 2019	# of Papers Published in 2020	# of Papers Published in 2021
4	6	20	41	58	132	151
11	6	16	37	52	122	146
3	4	15	36	51	117	145
5	4	15	35	48	116	143
10	4	15	34	46	115	136
1	3	14	33	45	114	135
2	3	14	33	43	110	133
6	3	13	31	43	110	131
7	3	13	31	43	110	131
8	3	13	30	42	109	131
9	3	13	30	42	108	130
16	3	12	29	40	106	126
13	3	12	29	40	103	124
14	3	12	28	38	101	121
17	3	11	28	36	99	116
12	2	11	26	36	96	116
15	2	11	26	34	94	114

Figure 7- This chart shows the SDG rank based on paper frequency from 2016- 2021. 2015 and 2022 were left out because the 2022 dataset did not encapsulate a full year of data and the 2015 dataset was limited (n=9). The lines between the years show the changing of the rank for FEW Nexus goals only.

3.3 SDG Research Spatial Scale Analysis

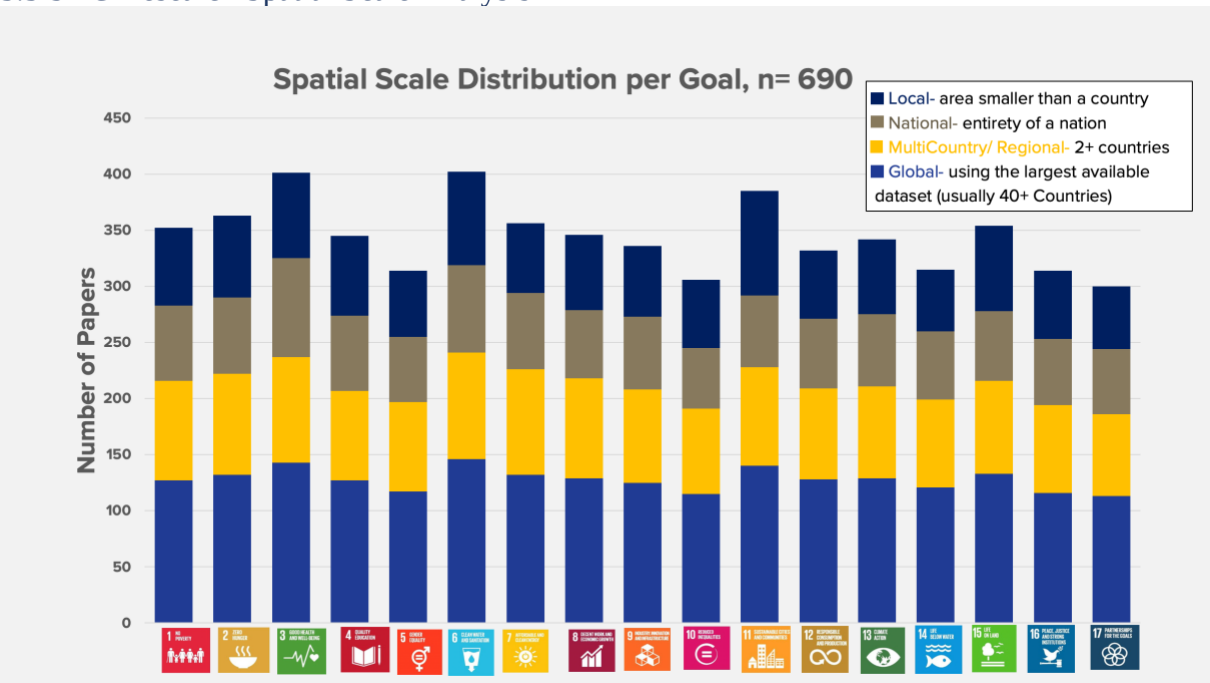

Figure 8 shows the distribution of scale levels across researched SDGs. This chart shows a relatively even spread of geographic scales across studies. Global scale studies account for 33.9% of the 690 papers, followed by MultiCountry/ Regional (23.6%), Local (21.9%), and National (20.6%).

To analyze what geographic scale SDGs are studied at, each study was labelled as local, national, multicounty, and global (details on each located in section 2.2.3 in the methodology). The most

common scale that was studied across all SDGs in the full dataset is global (n=234), followed by MultiCountry (n=163), Local (n=151), and National (n=141). The spread of the geographic scales was also subjected to a chi-square goodness of fit test and the resulting p-value is equal to 8.817e-07. This result indicates that the rate of geographic scales is likely not equally studied across the four categories.

The SDG with the highest percentage of global studies overall is SDG 12 (Responsible Consumption and Production) with 38.6% of all SDG 12 focused studies being conducted on a global scale. SDG 3 (health and wellness) had the lowest rate of globally sized studies. The SDG with the highest rate of MultiCountry conducted studies is SDG 7 (renewable energy) at 26.4% and the SDG with the lowest rate for this category is SDG 11 (sustainable cities and communities) at 22.9%. The SDG with the highest proportion of National scaled studies is SDG 3 (health and well-being) at 21.9% and the SDG with lowest proportion of this category is SDG 11 (sustainable cities and communities) at 16.6%. SDG 11 (sustainable cities and communities) had the highest rate of locally scaled studies at 24.2% and SDG 7 (renewable energy) had the lowest rate of locally conducted studies at 17.4%. Figure 9 details how SDG geographic scales are distributed between 2015- 2021. In this chart it is clear that while global studies remain dominant throughout the years, local studies have the largest growth rate. In 2020, local studies were the second highest studied scale and in 2021, local studies were tied in number with globally scaled studies (Figure 9).

SDG 11 (sustainable cities and communities) has a notably large number of local studies (24.2%), as it is the only SDG where the rate of local studies is higher than both its national and MultiCountry scaled studies. Most SDGs have category rankings that match the overall rankings. SDG 11 is the only SDG where the rate of local studies is higher than MultiCountry. See Table 5A for the exact rates for each geographic category broken down by SDG.

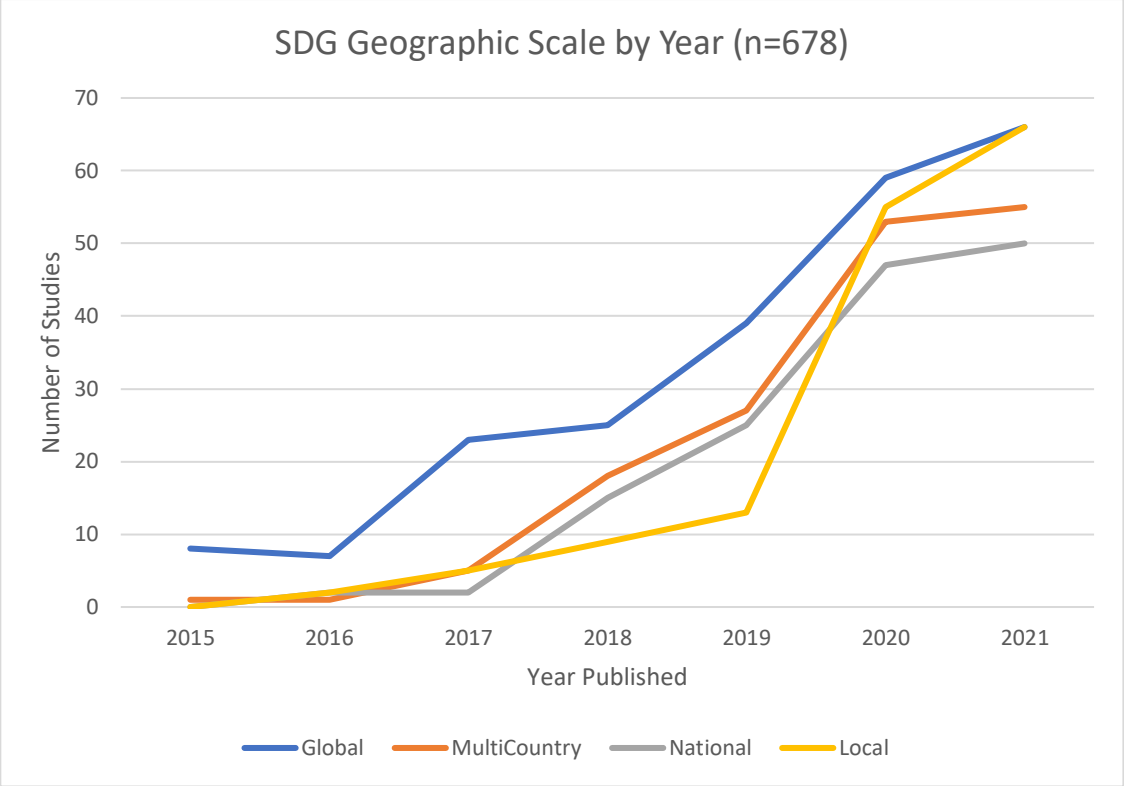

Figure 9 shows the geographic scale each study was conducted in broken down by year. Note that the year 2022 is not included because at the time of download, this study did not have a full year's worth of data.

3.4. Keyword Extraction Evaluation

Overall, there were 2214 unique keywords across the 688 studies analyzed. Acronyms and spelled out definitions were counted as one unique word. The keyword with the most frequency was "SDG" or "Sustainable Development Goal" which was expected due to that being a required factor in the search criteria. The second most cited keyword was "sustainable development" or "SD" appearing 69 times in study keywords which was closely followed by the word "sustainability" that appeared 67 times in paper keywords. The top reported SDG in paper keywords was SDG 6 (n= 8) which is predictable given that SDG 6 is also the top studied word. The top 25 keywords and corresponding frequencies are denoted in Table 2. Table 8A in appendix contains an extended version of this table that lists all keywords mentioned over 5 times across the 688 paper dataset.

Table 2 shows the top 25 keywords (or words with a frequency of 10 or greater) within this dataset of 688 papers. Note the similarity of some of the words (sustainable tourism vs. tourism, Agenda 2030 and 2030 Agenda, etc.) and the dominance of "SDGs", "SDG", "Sustainable Development Goals" and "Sustainable Development Goal".

Rank	Words	Keyword Frequency
1	Sustainable development goals (SDG)	520
2	Sustainable development (SD)	69

3	Sustainability	67
4	Sustainable Development Goal (SDG)	45
5	2030 Agenda	26
6	Indicators	23
7	Agenda 2030	20
8	Climate change	18
9	Corporate Social Responsibility	15
10	Ecosystem Services	15
11	Policy coherence	14
12	Circular economy	13
13	United Nations	13
14	Water	13
15	Network analysis	12
16	Poverty	12
17	synergies	12
18	COVID-19	11
19	Higher Education	11
20	Renewable energy	11
21	trade-offs	11
22	Millennium Development Goals (MDGs)	10
23	Sanitation	10
24	Sustainable tourism	10
25	tourism	10

Many keywords only appeared once in this search with 1788 words appearing one time across the 688 studies. This represents the wide variety of topics that the SDGs can connected to. As well as the slight differentiation between study topic terminology. For example, the term “2030 Agenda” having 20 appearances vs “Agenda 2030” having 20 appearances. Both refer to the 2015-2030 period that the SDGs were developed to monitor but due to a reversal in word order these terms appear as unique to those searching for them.

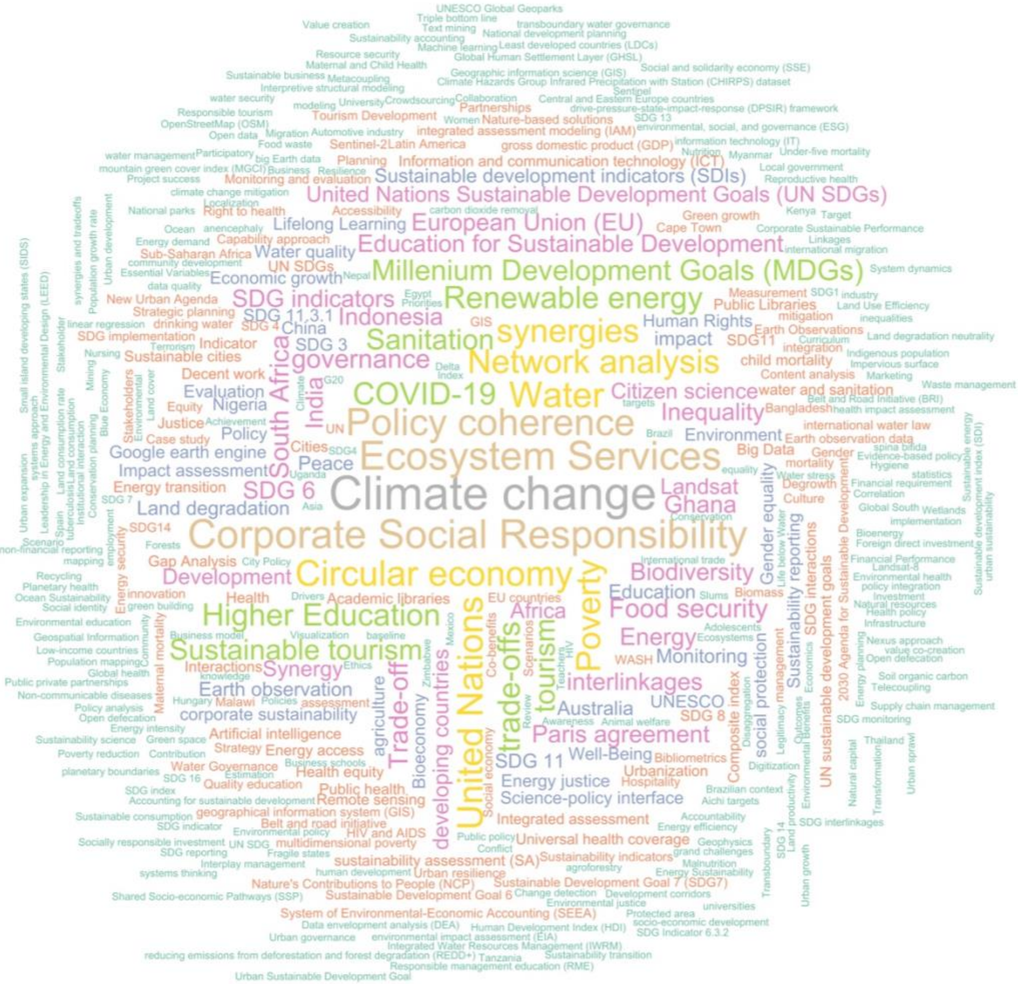

Figure 10 shows a word cloud that includes all keywords that were mentioned more than once excluding the words "SDG(s)", "sustainable development goal(s)", "sustainable development", and "sustainability (n=419 words). The size and colors of the words indicate how frequently the word was used, with the smallest words in green referencing all words with two mentions across keywords.

3.5 Interactions Between SDGs

There were 71 papers that analyzed interactions between the SDGs out of the 690 papers analyzed (approximately 10.3% of all literature analyzed). Figure 11 shows all interactions that were researched in our data set. Figure 11 demonstrates that the level that each SDG interaction was studied is near constant. It is important to note that each line in this chart reflects the extent that SDGs are influencing and affected by the other goals. The most studied influencing goal in this subset of data was SDG 1 (n= 827) followed by SDGs 2, 7, and 8 (all n= 771, respectively). The most studied influenced goal was SDG 13 (n= 802) followed by SDG 2 (n= 784) and then SDG 9 (n=762). See Figure 11 for more details.

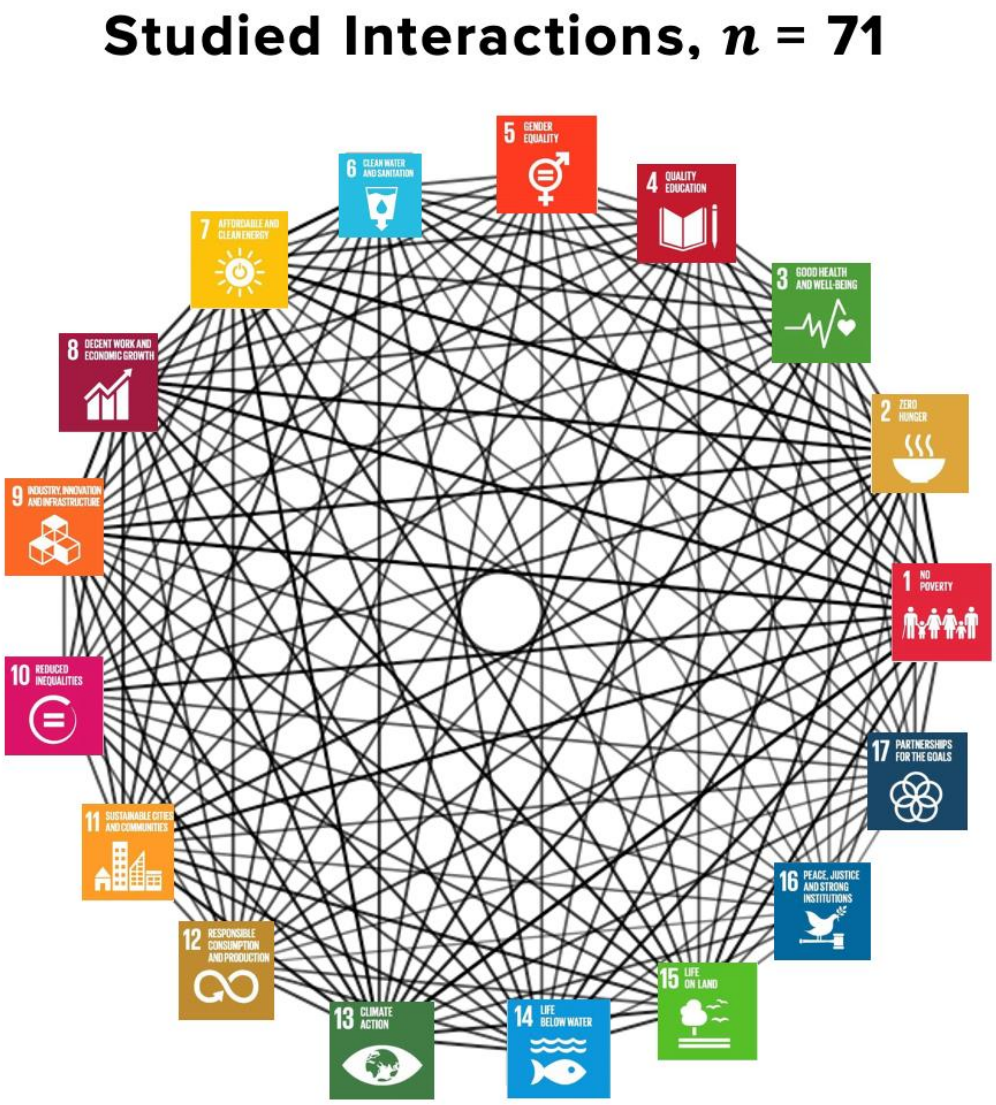

Figure 11 shows all interactions that were researched in our data set. The lines connecting the goals demonstrate the extent that interactions between two SDGs were studied. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$*, where* n_{XY} *is the total number of papers used. Metadata used to create this chart located in Table 9A.*

Figure 11 displays all the interactions that were marked as significant or notable across studies. It is important to note that the distinction of being labelled significant was left up to the studies discretion and therefore should be considered a subjective measure. Line width of this chart is notably thinner because significantly labeled interactions only constituted 29.5% of the studied interactions. Interactions that were labelled as significant most frequently are: impact of SDG 6 on SDG 3 (59.6% of all studied interactions reported as significant), SDG 15's impact on SDG 2 (56.9%), and SDG 2's impact on SDG 3 (56.5%). SDG 2 was the goal that had the most influencing and affected interactions with other goals with 37.1% of this goal's influencing interactions reported as significant and 42.3% the influenced interactions were labelled as significant.

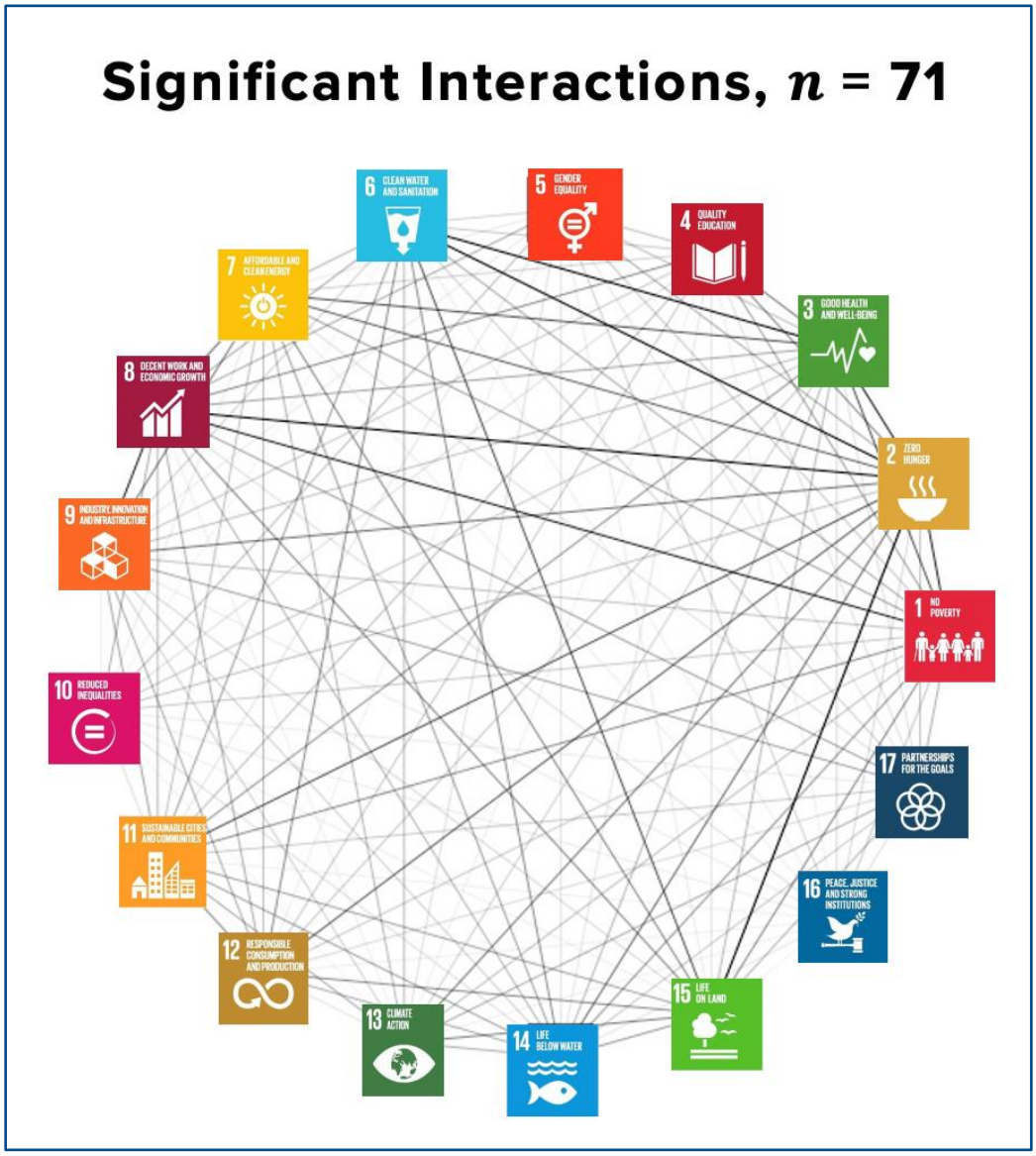

Figure 12 displays all the interactions that were marked as significant or notable across studies. The lines connecting the goals demonstrate the extent that interactions between two SDGs were studied. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$*, where* n_{XY} *is the total number of papers used. Metadata used to create this chart located in Table 10A.*

Synergies 3.5.1

Not all papers that studied interactions focused on the positive or negative effect of the relationship between the SDGs in question. Out of the 57 papers that did make this distinction, 9332 goal relationships were assessed by researchers for synergistic or positive interaction potential. Out of all the interactions studied (n= 12237), this constates 76.3% of the studies that were screened for a positive relationship.

The Studied synergies similar to studied interactions shows minimal amount of variation (Figures 11 and 13). Figure 13 cites fewer papers because not all studies related to SDG interactions specify the

directionality or positive and negative effects that interactions have on each goal. The most studied goal in terms of exploring its positive interactions with other SDGs was SDG 1 (n= 637), followed by SDG 7 and then SDG 8 (n= 597 and 584, respectively). The most studied goal in terms of how positive interactions impacted the specific goal is SDG 13 (n= 645) followed by SDGs 2 (n= 610) and SDG 15 (n= 592) (more information in Table 11A). 30.7% of the positive interactions studied were labelled as significant.

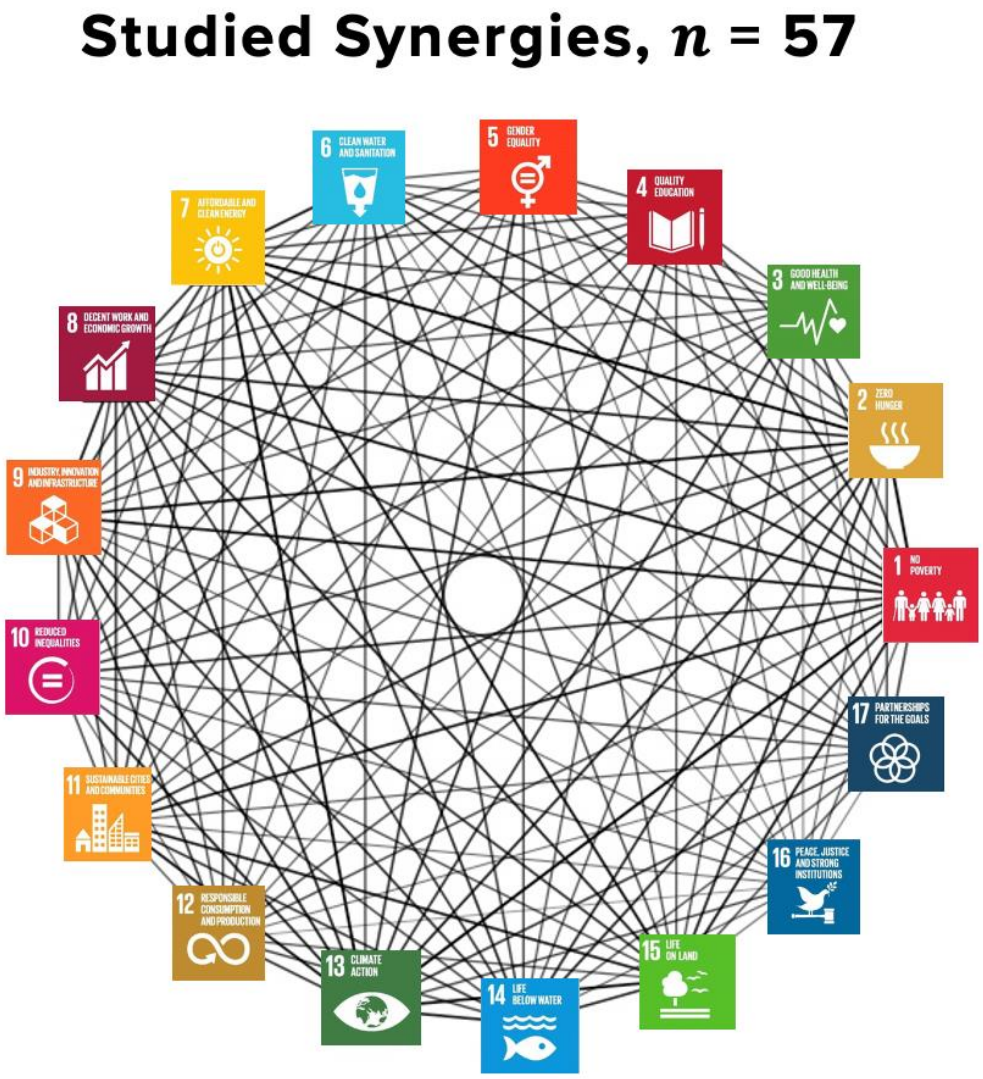

Figure 13 maps the positive interactions (synergies) between SDGs. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$, where n_{XY} is the total number of papers used. Metadata used to create this chart located in Table 11A.

Figure 14 maps the synergies between SDGs that were labelled as significant. The goals with highest percentage of reported significant synergies that influence other goals are: 1) SDG 2 (38.3%), 2) SDG 6 (37.2%), 3) SDG 7 (34.9%). Goals that are most influenced by significant synergies are: 1) SDG 2

(43.8% of interactions with other goals have a significant effect on this goal), 2) SDG 3 (43.1%), 3) SDG 1 (38.7%).

The highest reported significant synergy relations for these goals were SDG 8's effect on SDG 1 (n= 26 positive interactions labelled significant) and SDG 8 and SDG 6 influence on SDG 2(n=24 interactions each, respectively). SDG 2 is the most positively influencing and affected goal. The goals that are the most positively affected by SDG 2 are reported to be SDGs 1 and 9 n=20 reported significant synergy relationships for each respectively).

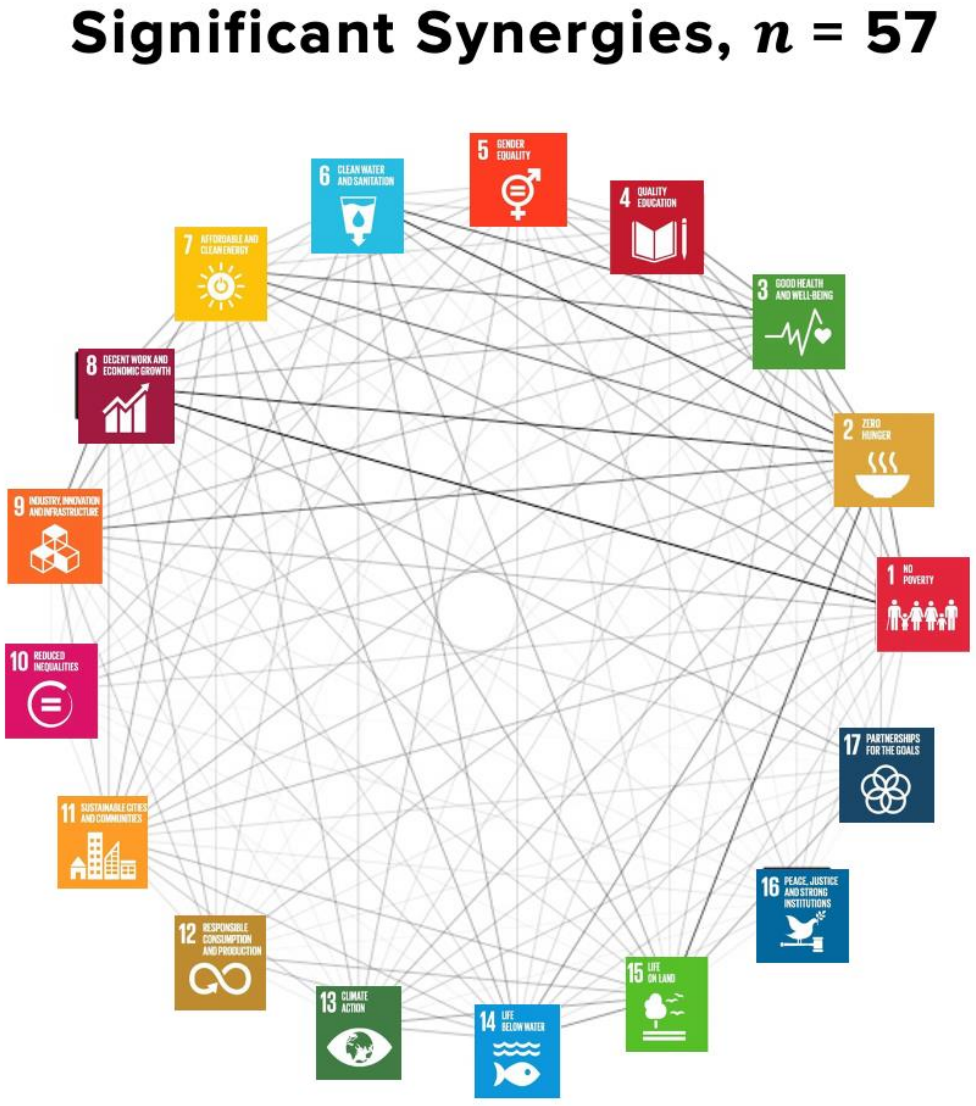

Figure 14 maps the synergies between SDGs that were labelled significant. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$*, where* n_{XY} *is the total number of papers used. Metadata used to create this chart located in Table 12A.*

Tradeoffs 3.5.2

The variation between goals where tradeoffs or negative interactions were studied is also very low like the interactions and synergies studied (Figures 11 and 13).

The most studied tradeoff in terms of influencing SDG was SDG 1 (n=569) followed by SDG 8 (n=524), and then SDG 2 (n= 512). The most studied tradeoff in terms of goals being influenced was SDG 2 (n= 526) followed by SDG 8 (n= 503) and then SDG 15 (n= 500).

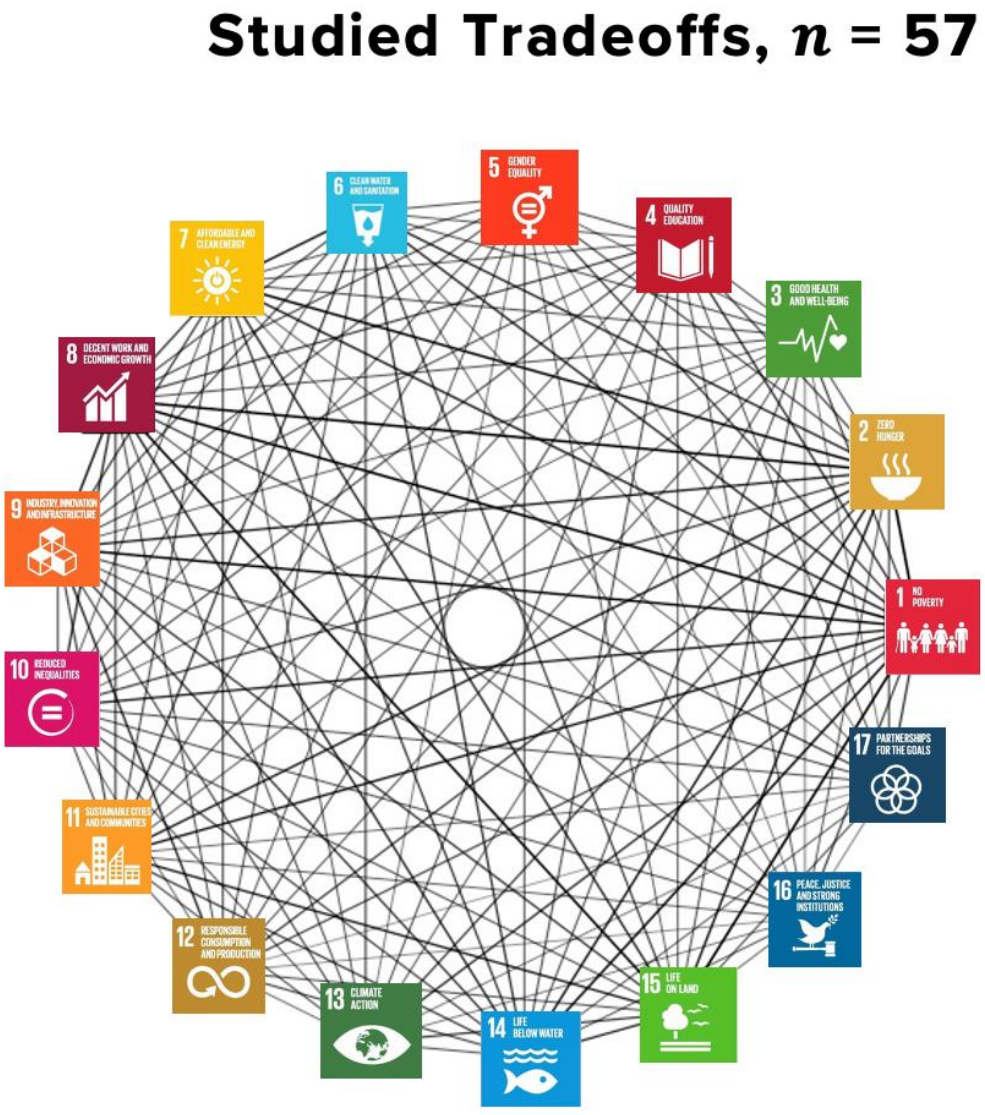

Figure 15 maps the negative interactions (Tradeoffs) between the SDGs. This chart is nearly identical to Figure 13 and likewise shows little variation among tradeoffs studied. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$*, where* n_{XY} *is the total number of papers used. Metadata used to create this chart located in Table 13A.*

Only 11.4% of tradeoffs studied were labelled as significant and this is reflected by the relatively thin line width in Figure 16. Goals with highest percentage of reported significant tradeoffs that influence

other goals: 1) SDG 12 (17.7%), 2) SDG 8 (17.1%), 3) SDG 7 (14.8%). Goals that are most influenced by significant tradeoffs: 1) SDG 8 (17.3%), 2) SDG 12 (16.7%), 3) SDG 15 (16.4%).

The highest reported tradeoff relations for these goals were SDG 12's effect on SDG 4 (n= 9 negative interactions labelled significant) and SDG 8's influence on SDG 15(n=12). SDG 8 is most negatively affected by SDG 15 (n= 10) and SDG 12 is most negatively affected by SDGs 7 and SDG 8 (n= 8 for each, respectively).

Figure 16 maps the tradeoffs that were labelled as significant. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$, where n_{XY} is the total number of papers used. Metadata used to create this chart located in Table 13A.

3.6 The FEW Nexus

To further relate this research to our team's expertise, our study highlights SDGs affiliated with the Food, Energy, Water (FEW) Nexus which typically includes SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), and SDG 7 (Affordable and Clean Energy). FEW Nexus goals had the highest positive influence on other SDGs with Goals 1, 2, and 3 being the most influenced (Figure 14). Also, SDG 2 was the goal that was most positively affected by other SDGs with SDGs 6 and 8 having the most consistent positive impact (n= 24 positive interactions documented across 57 studies for each goal, respectively). This is not to say that the FEW Nexus does not have any notable tradeoffs. SDG 7 was documented as one of the top tradeoff influencers (Figures 16 and 18) negatively affecting SDGs 2, 6, 12, and 15 to the greatest extent out of the SDG framework (n= 8, tradeoffs labelled significant across 57 papers for SDGs 2, 6, and 12 and n= 10 for SDG 15). Figures 17 and 18 demonstrate the significant synergies and tradeoffs within the FEW Goals. The largest amount of positive interactions documented within the FEW nexus is the affects that SDG 6 has on SDG 2 (n= 24 significant positive interactions reported). The next highest positive interaction relationships were SDG 7's impact on SDG 2 (n= 21) and SDG 2's influence on SDG 6 (n=17). See Figure 17 or Table 14A for more information.

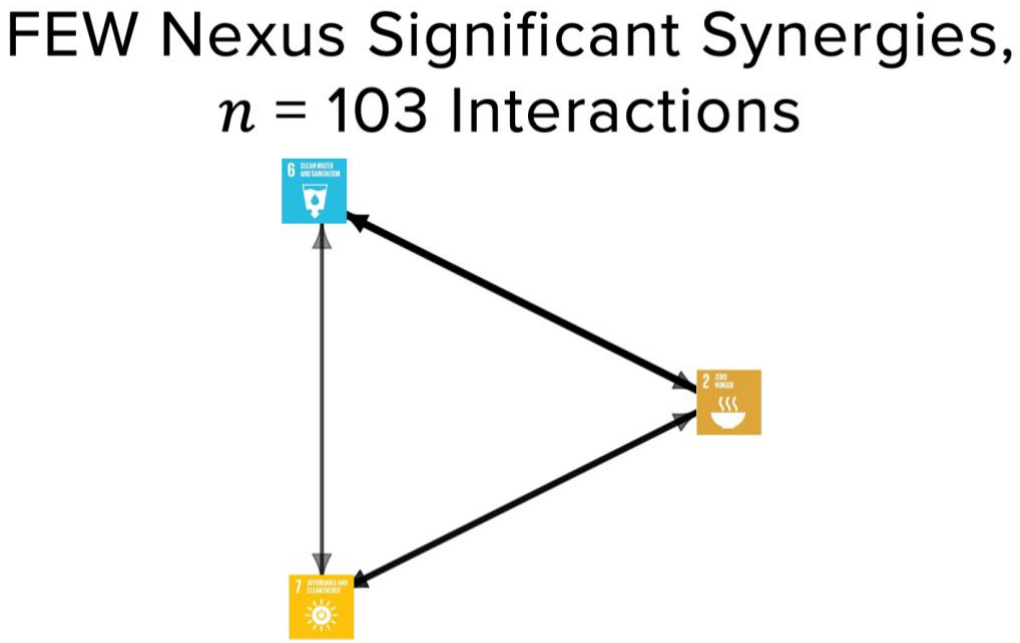

Figure 17 maps the positive relationships between the SDGs in the FEW Nexus. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$, where n_{XY} is the total number of papers used. Metadata used to create this chart located in Table 14A.

Figure 18 shows that despite SDG 2 having the strongest positive interactions, that a larger number of negative interactions are reported between SDG 7 and the other FEW Nexus goals. SDG 7 is affiliated with the top three reported significant interactions in this nexus. There are two pairs with the highest report of significant negative interactions is SDG 7's impact on SDGs 6 and 2 (n= 8 interactions for each). The next highest incidence of reported significant negative interactions within this nexus is SDG 2's impact on SDG 7 (n= 5). See Figure 18 or Table 16A for more information.

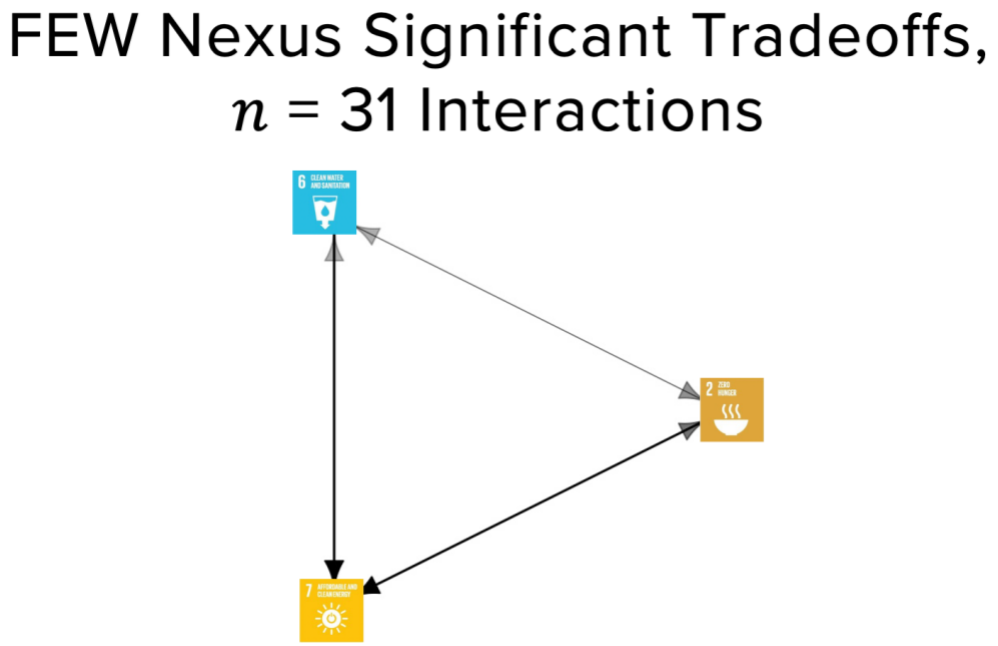

Figure 18 maps the negative interactions between the SDGs in the FEW Nexus. Equation for Line Width= line width and transparency given value $\frac{n_{12}}{n_{XY}}$, where n_{XY} is the total number of papers used. Metadata used to create this chart located in Table 15A.

3.7 SDG 2 Extended Analysis

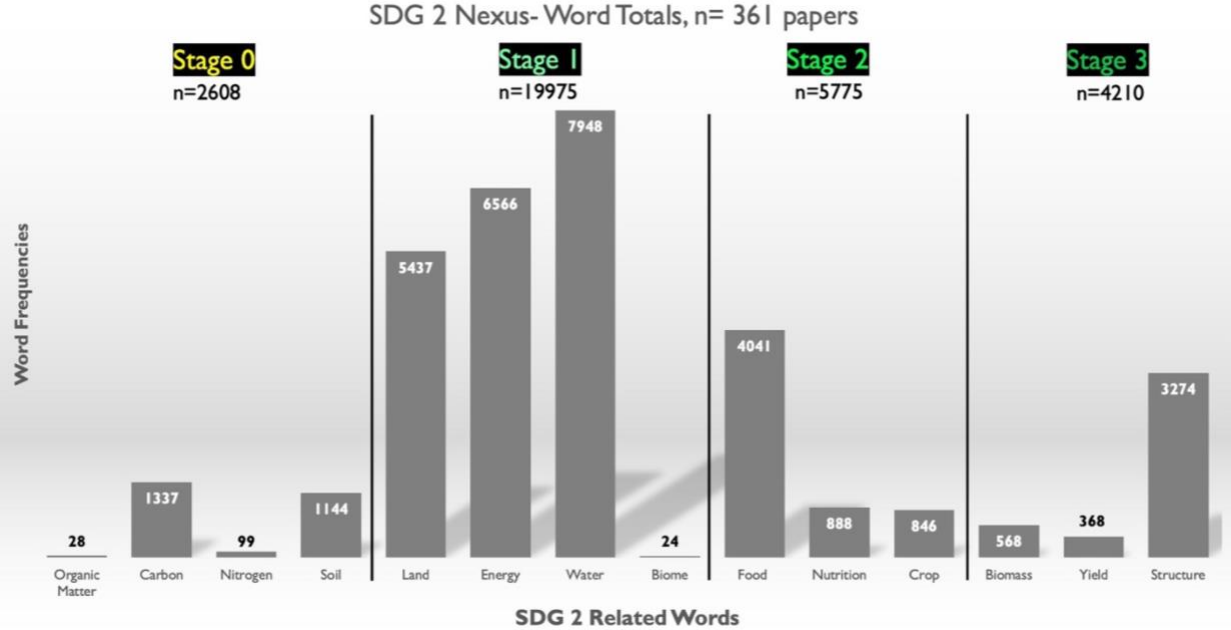

Figure 19 denotes the total amounts of each SDG 2 related words grouped in the stage system developed by Higgins, Abou Najm (2020). Sub-totals for each stage are listed above the words within that stage.

Stage 1 within the food pillar contains the highest word frequencies compared to other stages with the top three terms (water, energy, and land) all included in this category. The term "water" was the word with the highest frequency (n=7948) in this dataset and was used an average of 22 times per paper (Figure 19). Water was followed by the terms: "energy" (n= 6578, $n_{avg}\cong 18$), "land" (n=5448, $n_{avg}\cong 15$), food (n=4049, $n_{avg}\cong 11$), and structure (n=3284, $n_{avg}\cong 9$) (Figure 19). The words with the lowest frequencies were biome (n= 24), organic matter (n=28), and nitrogen (n=99), and each of these words had an average appearance rate of less than 1 time per paper (Figure 19).

Figures 19- 21 are histograms that demonstrate the number of papers that used a specific key term a specified number of times and equate this information into a frequency density function. Note that most words have a sharp decline after column one, indicating that most papers had relatively low mentions of the key terms with notable exceptions being higher frequency words like SDG, water, energy and land (Figures 19-21). Scientific words (measurement terms often used in agriculture like organic matter, nitrogen, biomass, yield) appear much less frequently than expected. For example, organic matter only appears a maximum of 5 times per paper in the 362-paper dataset. The words with higher total values tend to have a lower first column (e.g. water, energy, land, food). It is also important to note here that although some words have a larger x axis (e.g. energy and land spanning to

400 and 350, respectively) this does not correlate with ultimate highest word frequency with water being the most frequently used word (n= 7963) even though the highest frequency in a single paper for this word was only 263.

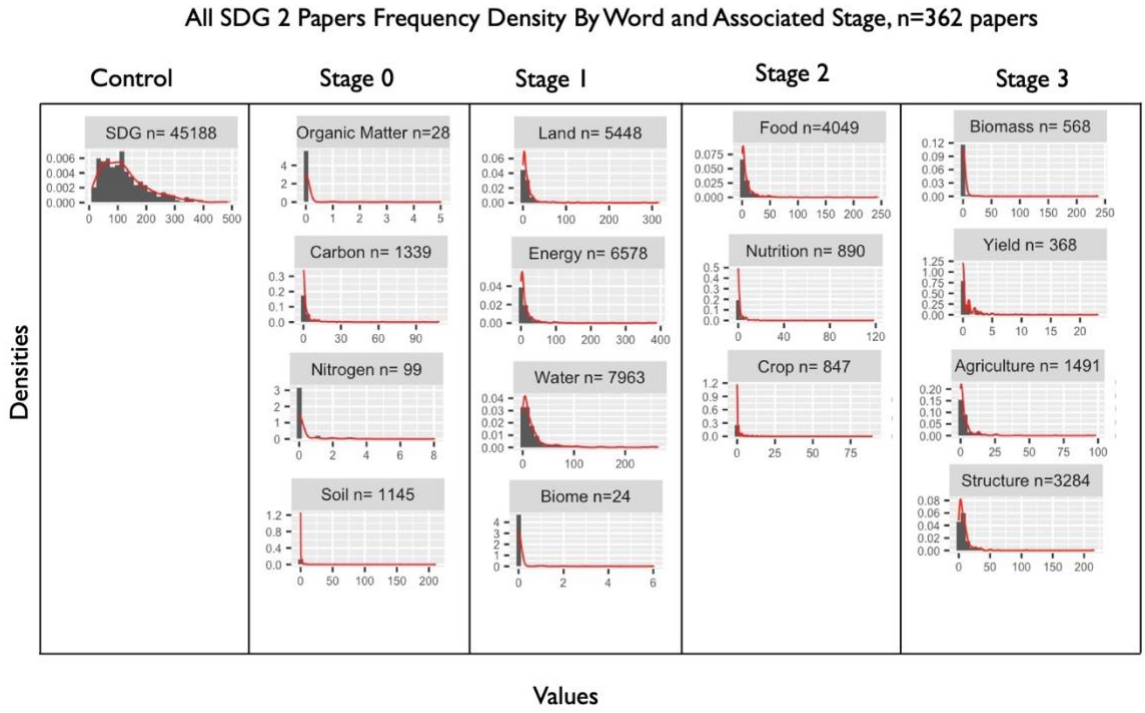

Figure 20 is a histogram that shows frequency densities at each key word count for all SDG Papers. The word "SDG" is used as a control for all SDG 2 Papers. The n at the topic refers to the total number of papers evaluated while the n values next to terms represent the number of times the term is used throughout the dataset. Each term is separated into its Stage.

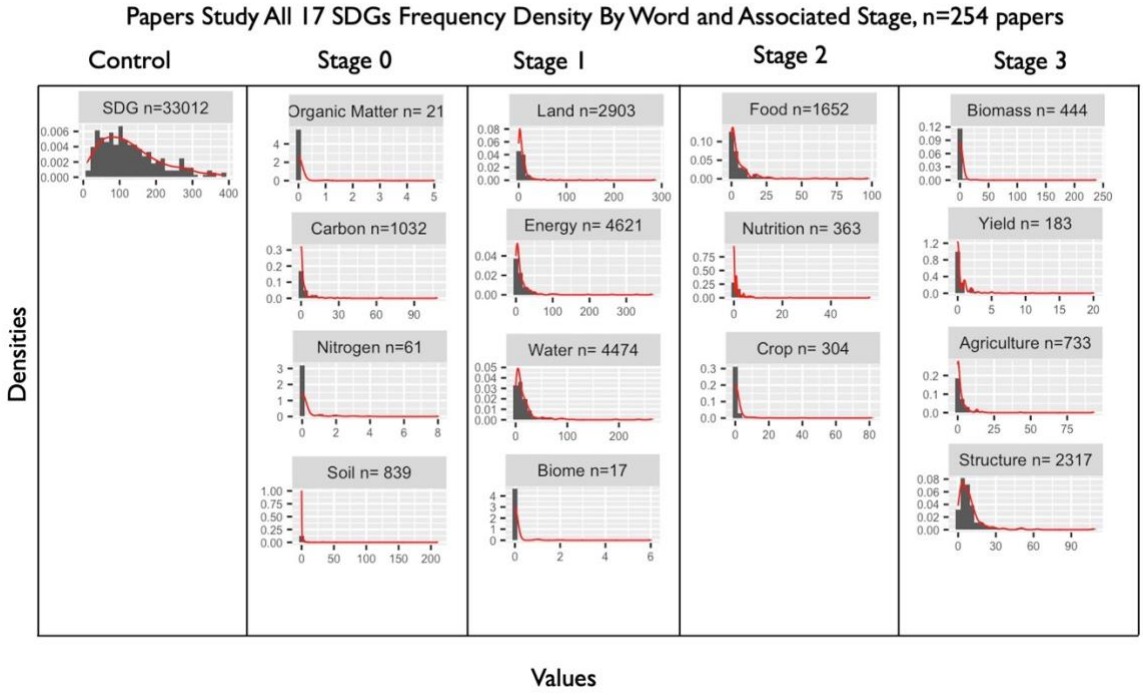

Figure 21 is a histogram that shows frequency densities at each key word count for papers that analyze all 17 SDGs. Note that one study from the 255 subgroup was no longer available for this analysis, hence the slightly lower paper number.

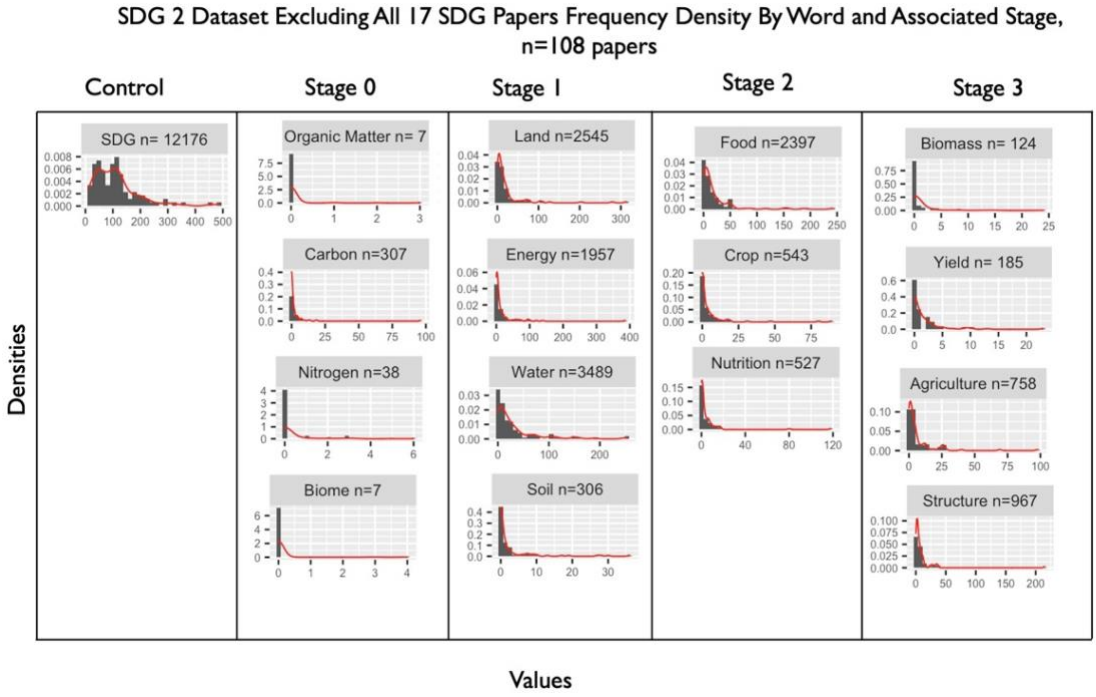

Figure 22 is a histogram that shows frequency densities at each key word count for all SDG Papers excluding those that analyze all 17 SDGs.

Figure 23 demonstrates the results of a correlation matrix of word use co-incidence within the dataset.

This matrix explored how one word's use impacted the probability that another specific word would

also be mentioned. It is important to note that this figure does not reflect the total number of appearances. It is also important to note that the original correlation matrix has negative values as well, but the chart below only represents the positive correlations. The results of the correlation matrix showed that the pair of terms with the highest correlation rate is “organic matter” and “soil” (n=0.70). The pairs with the next highest rate of positive correlation were: “Biomass” and “Crops” (n= 0.52) followed by “Crop” and “Organic Matter”. The associated correlation matrix is located in Appendix as Table 17A.

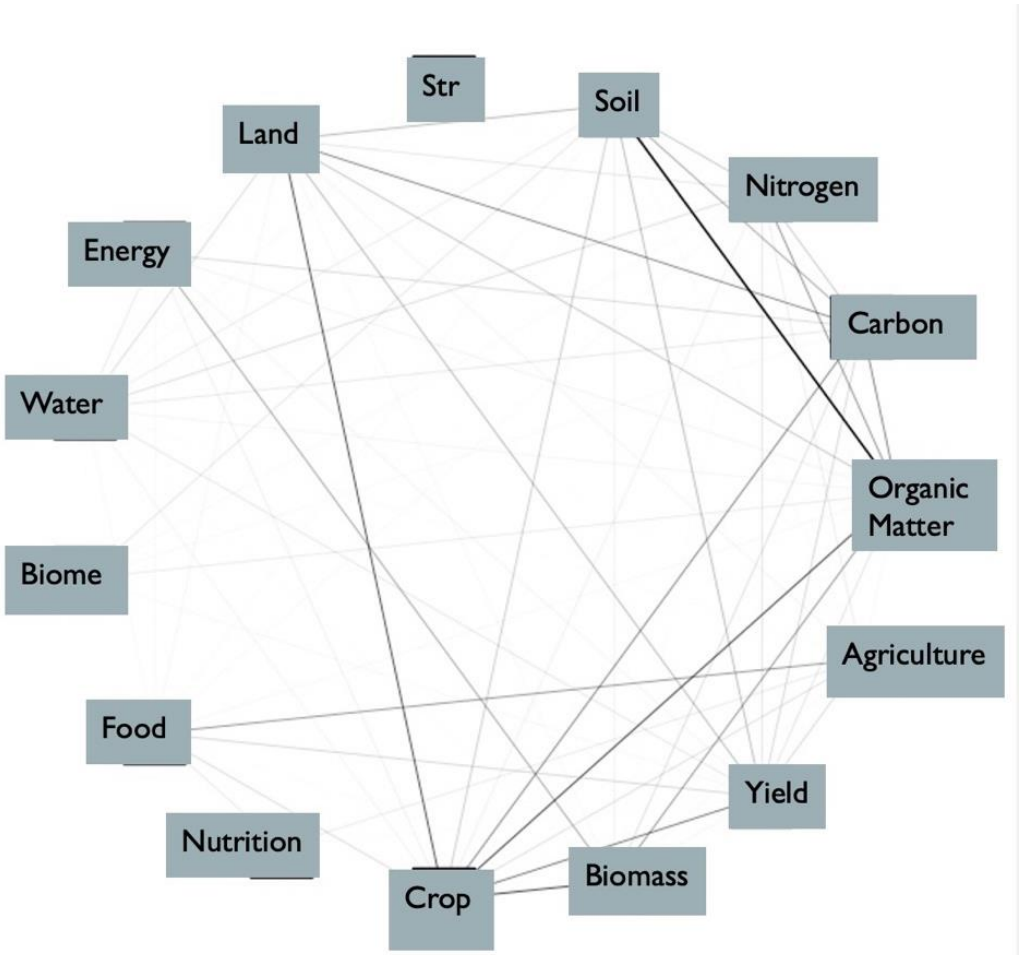

Figure 23 is a visual demonstration of the positive word usage correlation matrix located in Table 17A. Str=the word structure. This chart links words that are more likely to appear given the presence of the connecting word. Equation for Line Width= line width and transparency is determined by corresponding decimal in correlation matrix. This chart does not reflect the number of times term is mentioned.

4. Discussion

Ability of Academic Research to Address SDG Critiques

Many academic studies in our database commented on, provided, or/and acted to address critiques of the SDG framework. The following includes concrete examples of how academia-based research is currently addressing some of the most widespread SDG framework critiques.

In our full dataset there were papers that suggested monitoring frameworks and additions to indicators across many different SDGs (SDG 4-Tatto, 2021; SDGs 14 and 15-Pisupati, B, 2015; SDG 8-Frey, 2017; SDG 16- Goetz & Jenkins, 2016, SDG 11- Hansson, Arfvidsson, & Simon, 2019). The need for papers that suggest changes to SDG monitoring systems, likely stems from the many undefined grey indicators that still exist within the framework (UN Statistical Commission, 2016; Georgeson & Maslin, 2018). These papers are a beneficial resource for public and private sector groups that aim to study SDG indicators or targets that still may have an unclear methodology. There was also a group of papers that suggested alternative funding and implementation methods that are more appropriate for low-income countries (Munro, van der Horst, Healy, 2017; Budalamah, El-Kholei, Al-Jayyousi, 2019; Johansen & Vestvik, 2020). This subset of papers is also a valuable resource in diversifying how progress can be made when considering different countries' contextual setting and resource availability.

One common critique of the SDG indicator system is that it is resource extensive and often impractical to monitor on local scale (Georgeson & Maslin, 2018; Hansson, Arfvidsson, Simon, 2019; Alaimo & Maggino, 2020). Due to the VNR self-reporting system the UN has implemented, it was assumed that the national scale would be studied by academic sources at a higher rate. Our research unveiled that in the academic realm, this is not case given that the national scale was the scale studied least among the 690-paper dataset (Figure 8). Although the local scale was only slightly more than national overall (20.6% national compared to 21.9% studied on local scale) some SDGs such as SDG 11 exhibited high amounts of locally implemented studies. It is also worth noting the high growth rate of locally conducted SDG studies in recent years. The number of locally scaled studies was equal to

the number of global studies during the year 2021 (Figure 9). The trend of increasing local studies in academia, highlights academia's ability to contribute to the perceived low amount of local SDG monitoring. Many countries do not have the institutional or economic ability to monitor SDG targets on a local scale but many studies that are funded by public and private sector money may have the capability to somewhat compensate for this by measuring SDG indicator status on a local scale in these countries. In this way, academia can act as an initial bridge between funding sources to track indicators on a local scale.

SDG Research Recommendations and Future Research

One of the main goals of this research was to explore SDG trends and use this information for future research recommendations. The following are some research recommendations and overall notes developed based off study results:

- Papers that include all 17 SDGs do important work for promoting research some of the lesser studied goals and often, shed light on their progress in different geographic contexts. Studying as many of SDGs as possible should be a priority for all researchers. In doing so they are exploring the progress and impact of not only the widely studied goals, but also those that have to tendency to be overlooked.

- SDG 10 Reduced Inequalities needs more attention. In our dataset, there was only one study that focused SDG 10 alone and it was a global commentary on this goal (Figure 4). Very little, if any, research on this goal occurs on a national or localized scale, which is concerning.

- SDGs being studied together at higher rates does not translate to a high rate of reported significant interactions. For instance, SDGs 3 and 6 are reported as having a strong synergistic relationship but are not noted as being studied together often (Figures 5 and 12). Efforts should be made to prioritize studying SDGs with high reported rates of interaction instead of SDGs that we intuitively think would complement or have tradeoffs with each other.

- Synergistic relationships between goals need to be prioritized to reach the SDG framework's goals set for 2030. SDG 2 and other goals with high synergistic potential are very promising study topics in this respect. SDG 2 is reported to be not only to be highly synergistic with natural resource-oriented goals (SDGs 6, 15) but with economic related goals as well (SDGs 1, 8, and 9) (Figure 14 and Table 12A). Intentional research that explores noted synergies on different geographic scales and implementing policy that supports the synergistic relationships would go a long way in supporting the 2030 SDG benchmarks.

- Tradeoffs between goals also need to be addressed to reach SDG framework benchmarks. The relative high tradeoffs that both SDG 8 and SDG 12 are reported to experience with other goals is also a subject that deserves more scrutiny (Figure 17). Some tradeoffs, such as the relationship of economic and environmental spheres (SDG 8 and SDG 15), are well documented. However, some of the highest reported significant tradeoffs are between sectors that are generally thought of as neutral or complementary and should be studied further to determine the tradeoffs true extent. SDGs 8 and 12 are both generally more understudied goals (Figures 1 and 4) that had a higher rate of globally implemented studies than other SDGs (Figure 8). Further researching SDGs 8 and 12 tradeoffs on smaller scales would likely highlight ways to lessen the tradeoff impact on 2030 SDG target completion.

Food, Water, Energy Nexus Takeaways

Our research findings confirm the perceived importance of the FEW Nexus with SDG 6 being the most studied goal while SDGs 2 and 7 also are studied more than average (Figure 3). In terms of interactions, research patterns can shed further light on how the FEW Nexus behaves internally and how this SDG cluster impacts other goals.

More research needs to be conducted on how SDG 7 operates within the FEW Nexus because it was the largest source of tradeoffs within the nexus (Figure 18). Although the interaction results offered by

this study cannot provide quantification of the extent of this tradeoff due to the diversity of source data, referring to these papers themselves can reveal a few explanations and patterns. For example, there were 5 papers within that cited significant negative tradeoffs between SDG 2 and SDG 7, which was the FEW Nexus' top tradeoff (Figure 18). Two targets are specifically analyzed and cited as tradeoffs within two of the five papers: targets 2.5 (preserving genetic diversity of plant and livestock) and 7.2 (energy share in total energy consumption) (Ramos & Laurenti, 2020; Ronzon & Sanjuán, 2020). Multiple papers in this small dataset also cited resource and biofuel competition between SDG 2 and SDG 7 as partially reasoning behind the tradeoff status (Pham-Truffert et. Al, 2020; Ronzon & Sanjuán, 2020). Further analysis on specific papers on reported significant synergies and tradeoffs (Figures 14, 16, 17, and 18) can shed light on specific patterns within the FEW Nexus.

Information from the SDG 2 key term frequency can also shed light on how SDG 2 interacts with SDGs 6 and 7. The words "water" and "energy" were included in this analysis and were the two most frequently used words across all key terms used in this analysis (Figures 19- 22). A correlation matrix also noted which terms were most likely to be used in tandem with other SDG 2 related terms (Figure 23). Figure 23 shows that water does not have a strong correlation with any one SDG 2 related term which leads to the conclusion that water is used often within SDG 2 research across stages and affiliated terms. The term "energy"; however, seems to be most correlated with the word biomass (Figure 23). This would make sense given that as previously mentioned, there seems to be biofuel competition between SDGs 2 and 7. Noting that scientific words are much less frequently used in SDG 2 research may also have implications about which stage SDGs 6 and 7 are typically studied at (Higgins, Abou Najm, 2020).

Conclusion

These research trends are important to note because they can serve as an indication of which SDGs are understudied or underutilized. We can use the knowledge of how SDG research is distributed across geography and time as well as how they interact. This knowledge advances the SDG framework's completion and better addresses gaps that remain. In this study, it was shown that each

of the 17 SDGs are studied to some extent although there is a large amount of variation (Figures 3 and 4). The top three studied SDGs are 1- SDG 6 (water and sanitation), 2- SDG 3 (health and well-being), and 3- SDG 11 (sustainable cities and communities) (Figure 3). The level of variation only increases once papers that focus on all 17 SDGs are excluded and even more so when only single SDG papers are analyzed (Figure 4). SDG research has steadily grown throughout the 2015- 2021 with SDGs 3, 6, and 11 being the top researched goals between 2019 and 2021 (Figure 7). The spatial scale that SDGs are studied also exhibits a significant degree of variation. Global is the scale that is most studied followed by multicountry/ regional, local, and national scaled studies. Between 2015-2021, the popularity of locally conducted studies in SDG research has skyrocketed and as of 2021, the local scale is studied at the same rate as global studies (Figure 9). This is somewhat surprising given that a large critique of the SDG framework in literature is their inability to be applied to local scales. Analysis of the keywords that are affiliated with SDG research shows that a diverse number of sectors and research topics can be connected to the SDGs and contribute to SDG progress. In terms of interactions, it is uplifting to find that many researchers are identifying more synergistic interactions between goals compared to tradeoffs (Figures 14 and 16).

Through the process of analyzing these trends a detailed log of the 690 evaluated papers was created. In addition to the notes listed above, our team also will publish this database of SDG papers and corresponding information as an open-source resource. This database will be released as an open-source tool for researchers in the hope that experts will apply their perspective to this data and generate conclusions that our team cannot. We acknowledge that there are many directions that this data can be taken in, depending on one's area of expertise. With the release of this study and the full database, we hope that SDG research can be explored to a greater extent. The SDG framework itself allows a unique opportunity to study how diverse sectors interact with each other on different geographic scales. This opportunity to contribute to the SDG framework's ultimate goal of sustainability by 2030 has been taken by many researchers who come from a diverse number of disciplines. We hope that by providing these resources, that it is easier for future researchers to draw

from a centralized SDG data source and aid in adding to the knowledge base that will help bring the 2030 benchmarks to fruition.

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6. Appendices

Appendix A

Goal 1. End poverty in all its forms everywhere	
1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	1.1.1 Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	1.2.1 Proportion of population living below the national poverty line, by sex and age
	1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable
1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	1.4.1 Proportion of population living in households with access to basic services
	1.4.2 Proportion of total adult population with secure tenure rights to land, (a) with legally recognized documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure
1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)
	1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
1.a Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions	1.a.1 Total official development assistance grants from all donors that focus on poverty reduction as a share of the recipient country's gross national income
	1.a.2 Proportion of total government spending on essential services (education, health and social protection)
1.b Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions	1.b.1 Pro-poor public social spending
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture	
	2.1.1 Prevalence of undernourishment

2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age
	2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
	2.2.3 Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage)
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment	2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size
	2.3.2 Average income of small-scale food producers, by sex and indigenous status
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed	2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities
	2.5.2 Proportion of local breeds classified as being at risk of extinction
2.a Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	2.a.1 The agriculture orientation index for government expenditures
	2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
2.b Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round	2.b.1 Agricultural export subsidies

2.c Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	2.c.1 Indicator of food price anomalies
Goal 3. Ensure healthy lives and promote well-being for all at all ages	
3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	3.1.1 Maternal mortality ratio
	3.1.2 Proportion of births attended by skilled health personnel
3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births	3.2.1 Under-5 mortality rate
	3.2.2 Neonatal mortality rate
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	3.3.1 Number of new HIV infections per 1,000 uninfected population, by sex, age and key populations
	3.3.2 Tuberculosis incidence per 100,000 population
	3.3.3 Malaria incidence per 1,000 population
	3.3.4 Hepatitis B incidence per 100,000 population
	3.3.5 Number of people requiring interventions against neglected tropical diseases
3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease
	3.4.2 Suicide mortality rate
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders
	3.5.2 Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	3.6.1 Death rate due to road traffic injuries
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes	3.7.1 Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods
	3.7.2 Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age group
3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all	3.8.1 Coverage of essential health services
	3.8.2 Proportion of population with large household expenditures on health as a share of total household expenditure or income
	3.9.1 Mortality rate attributed to household and ambient air pollution

3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination	3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
	3.9.3 Mortality rate attributed to unintentional poisoning
3.a Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate	3.a.1 Age-standardized prevalence of current tobacco use among persons aged 15 years and older
3.b Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all	3.b.1 Proportion of the target population covered by all vaccines included in their national programme
	3.b.2 Total net official development assistance to medical research and basic health sectors
	3.b.3 Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis
3.c Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States	3.c.1 Health worker density and distribution
3.d Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks	3.d.1 International Health Regulations (IHR) capacity and health emergency preparedness
	3.d.2 Percentage of bloodstream infections due to selected antimicrobial-resistant organisms[i]
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	
4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes	4.1.1 Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex
	4.1.2 Completion rate (primary education, lower secondary education, upper secondary education)
4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education	4.2.1 Proportion of children aged 24-59 months who are developmentally on track in health, learning and psychosocial well-being, by sex[i]
	4.2.2 Participation rate in organized learning (one year before the official primary entry age), by sex
4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university	4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex
4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill

4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations	4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated
4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy	4.6.1 Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all	4.a.1 Proportion of schools offering basic services, by type of service
4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries	4.b.1 Volume of official development assistance flows for scholarships by sector and type of study
4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States	4.c.1 Proportion of teachers with the minimum required qualifications, by education level[i]
Goal 5. Achieve gender equality and empower all women and girls	
5.1 End all forms of discrimination against all women and girls everywhere	5.1.1 Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex
5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation	5.2.1 Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age
	5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence
5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation	5.3.1 Proportion of women aged 20–24 years who were married or in a union before age 15 and before age 18
	5.3.2 Proportion of girls and women aged 15–49 years who have undergone female genital mutilation/cutting, by age

5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate	5.4.1 Proportion of time spent on unpaid domestic and care work, by sex, age and location
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life	5.5.1 Proportion of seats held by women in (a) national parliaments and (b) local governments
	5.5.2 Proportion of women in managerial positions
5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences	5.6.1 Proportion of women aged 15–49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care
	5.6.2 Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education
5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure
	5.a.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control
5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women	5.b.1 Proportion of individuals who own a mobile telephone, by sex
5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels	5.c.1 Proportion of countries with systems to track and make public allocations for gender equality and women's empowerment
Goal 6. Ensure availability and sustainable management of water and sanitation for all	
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all	6.1.1 Proportion of population using safely managed drinking water services
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of domestic and industrial wastewater flows safely treated
	6.3.2 Proportion of bodies of water with good ambient water quality
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources

6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time
6.a By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.b Support and strengthen the participation of local communities in improving water and sanitation management	6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all	
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Proportion of population with access to electricity
	7.1.2 Proportion of population with primary reliance on clean fuels and technology
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption
7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support	7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	8.1.1 Annual growth rate of real GDP per capita
8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	8.2.1 Annual growth rate of real GDP per employed person

8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	8.3.1 Proportion of informal employment in total employment, by sector and sex
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead	8.4.1 Material footprint, material footprint per capita, and material footprint per GDP
	8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	8.5.1 Average hourly earnings of employees, by sex, age, occupation and persons with disabilities
	8.5.2 Unemployment rate, by sex, age and persons with disabilities
8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training	8.6.1 Proportion of youth (aged 15–24 years) not in education, employment or training
8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms	8.7.1 Proportion and number of children aged 5–17 years engaged in child labour, by sex and age
8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment	8.8.1 Fatal and non-fatal occupational injuries per 100,000 workers, by sex and migrant status
	8.8.2 Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status
8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products	8.9.1 Tourism direct GDP as a proportion of total GDP and in growth rate
8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all	8.10.1 (a) Number of commercial bank branches per 100,000 adults and (b) number of automated teller machines (ATMs) per 100,000 adults
	8.10.2 Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider
8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-related Technical Assistance to Least Developed Countries	8.a.1 Aid for Trade commitments and disbursements
8.b By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization	8.b.1 Existence of a developed and operationalized national strategy for youth employment, as a distinct strategy or as part of a national employment strategy
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	

9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	9.1.1 Proportion of the rural population who live within 2 km of an all-season road
	9.1.2 Passenger and freight volumes, by mode of transport
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries	9.2.1 Manufacturing value added as a proportion of GDP and per capita
	9.2.2 Manufacturing employment as a proportion of total employment
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets	9.3.1 Proportion of small-scale industries in total industry value added
	9.3.2 Proportion of small-scale industries with a loan or line of credit
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO_2 emission per unit of value added
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	9.5.1 Research and development expenditure as a proportion of GDP
	9.5.2 Researchers (in full-time equivalent) per million inhabitants
9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities	9.b.1 Proportion of medium and high-tech industry value added in total value added
9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020	9.c.1 Proportion of population covered by a mobile network, by technology
Goal 10. Reduce inequality within and among countries	
10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average	10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population
10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status	10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities

10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard	10.3.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	10.4.1 Labour share of GDP
	10.4.2 Redistributive impact of fiscal policy[4]
10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations	10.5.1 Financial Soundness Indicators
10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions	10.6.1 Proportion of members and voting rights of developing countries in international organizations
10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies	10.7.1 Recruitment cost borne by employee as a proportion of monthly income earned in country of destination
	10.7.2 Number of countries with migration policies that facilitate orderly, safe, regular and responsible migration and mobility of people
	10.7.3 Number of people who died or disappeared in the process of migration towards an international destination[i]
	10.7.4 Proportion of the population who are refugees, by country of origin
10.a Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements	10.a.1 Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff
10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes	10.b.1 Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows)
10.c By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent	10.c.1 Remittance costs as a proportion of the amount remitted
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable	
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing

11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate
	11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal)
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
	11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
	11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	11.a.1 Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space
11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	*No suitable replacement indicator was proposed. The global statistical community is encouraged to work to develop an indicator that could be proposed for the 2025 comprehensive review. See E/CN.3/2020/2, paragraph 23.*
Goal 12. Ensure sustainable consumption and production patterns	

12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP
	12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1 (a) Food loss index and (b) food waste index
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
	12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	12.6.1 Number of companies publishing sustainability reports
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12.7.1 Degree of sustainable public procurement policies and action plan implementation
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita)
12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability

12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption)[i]
Goal 13. Take urgent action to combat climate change and its impacts[3]	
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
	13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
	13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
	13.2.2 Total greenhouse gas emissions per year
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment
13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the $100 billion commitment through to 2025
13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	13.b.1 Number of least developed countries and small island developing States with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development	
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density[i]

14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Number of countries using ecosystem-based approaches to managing marine areas
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation[4]	14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries
14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries	14.a.1 Proportion of total research budget allocated to research in the field of marine technology
14.b Provide access for small-scale artisanal fishers to marine resources and markets	14.b.1 Degree of application of a legal/regulatory/ policy/institutional framework which recognizes and protects access rights for small-scale fisheries
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area
	15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity
	15.4.2 Mountain Green Cover Index
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index
15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked
15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting
15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems	15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments

15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation	15.b.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments
15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities	15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	
16.1 Significantly reduce all forms of violence and related death rates everywhere	16.1.1 Number of victims of intentional homicide per 100,000 population, by sex and age
	16.1.2 Conflict-related deaths per 100,000 population, by sex, age and cause
	16.1.3 Proportion of population subjected to (a) physical violence, (b) psychological violence and (c) sexual violence in the previous 12 months
	16.1.4 Proportion of population that feel safe walking alone around the area they live
16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children	16.2.1 Proportion of children aged 1–17 years who experienced any physical punishment and/or psychological aggression by caregivers in the past month
	16.2.2 Number of victims of human trafficking per 100,000 population, by sex, age and form of exploitation
	16.2.3 Proportion of young women and men aged 18–29 years who experienced sexual violence by age 18
16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all	16.3.1 Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms
	16.3.2 Unsentenced detainees as a proportion of overall prison population
	16.3.3 Proportion of the population who have experienced a dispute in the past two years and who accessed a formal or informal dispute resolution mechanism, by type of mechanism
16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime	16.4.1 Total value of inward and outward illicit financial flows (in current United States dollars)
	16.4.2 Proportion of seized, found or surrendered arms whose illicit origin or context has been traced or established by a competent authority in line with international instruments
16.5 Substantially reduce corruption and bribery in all their forms	16.5.1 Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months

	16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months
16.6 Develop effective, accountable and transparent institutions at all levels	16.6.1 Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar)
	16.6.2 Proportion of population satisfied with their last experience of public services
16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	16.7.1 Proportions of positions in national and local institutions, including (a) the legislatures; (b) the public service; and (c) the judiciary, compared to national distributions, by sex, age, persons with disabilities and population groups
	16.7.2 Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group
16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance	16.8.1 Proportion of members and voting rights of developing countries in international organizations
16.9 By 2030, provide legal identity for all, including birth registration	16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age
16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements	16.10.1 Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months
	16.10.2 Number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information
16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime	16.a.1 Existence of independent national human rights institutions in compliance with the Paris Principles
16.b Promote and enforce non-discriminatory laws and policies for sustainable development	16.b.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development	
Finance	
17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	17.1.1 Total government revenue as a proportion of GDP, by source
	17.1.2 Proportion of domestic budget funded by domestic taxes

17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/GNI) to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries	17.2.1 Net official development assistance, total and to least developed countries, as a proportion of the Organization for Economic Cooperation and Development (OECD) Development Assistance Committee donors' gross national income (GNI)
17.3 Mobilize additional financial resources for developing countries from multiple sources	17.3.1 Foreign direct investment, official development assistance and South-South cooperation as a proportion of gross national income
	17.3.2 Volume of remittances (in United States dollars) as a proportion of total GDP
17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress	17.4.1 Debt service as a proportion of exports of goods and services
17.5 Adopt and implement investment promotion regimes for least developed countries	17.5.1 Number of countries that adopt and implement investment promotion regimes for developing countries, including the least developed countries
Technology	
17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism	17.6.1 Fixed Internet broadband subscriptions per 100 inhabitants, by speed[5]
17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed	17.7.1 Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology	17.8.1 Proportion of individuals using the Internet
Capacity-building	
17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation	17.9.1 Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries

Trade	
17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda	17.10.1 Worldwide weighted tariff-average
17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020	17.11.1 Developing countries' and least developed countries' share of global exports
17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access	17.12.1 Weighted average tariffs faced by developing countries, least developed countries and small island developing States
Systemic issues	
Policy and institutional coherence	
17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence	17.13.1 Macroeconomic Dashboard
17.14 Enhance policy coherence for sustainable development	17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development
17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development	17.15.1 Extent of use of country-owned results frameworks and planning tools by providers of development cooperation
Multi-stakeholder partnerships	
17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries	17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals
17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships	17.17.1 Amount in United States dollars committed to public-private partnerships for infrastructure
Data, monitoring and accountability	
17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts	17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring
	17.18.2 Number of countries that have national statistical legislation that complies with the Fundamental Principles of Official Statistics
	17.18.3 Number of countries with a national statistical plan that is fully funded and under implementation, by source of funding
17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable	17.19.1 Dollar value of all resources made available to strengthen statistical capacity in developing countries

development that complement gross domestic product, and support statistical capacity-building in developing countries	17.19.2 Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration

Table A 1- This table lists all of the indicators and targets of the 17 SDGs organized within the SDG it pertains to. Table information refers to information contained in the Annex of the resolution adopted by the General Assembly on 6 July 2017 (UN Statistical Commission (2016)- Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Development (A/RES/71/313)

SDGs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Papers Discussing All 17 SDGs	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255	255
Remaining Papers Pertaining to Specific SDG	97	108	146	90	59	147	101	91	81	51	130	77	87	60	99	59	45
SDG Frequency Totals	352	363	401	345	314	402	356	346	336	306	385	332	342	315	354	314	300

Table A 2- This table shows the total frequency for SDGs studied from the 690 papers analyzed. The first row lists the amount of papers that study all 17 SDGs, the second row pertains to studies within the total frequency that do not study all 17 SDGs. The third row shows the total amount of papers that study a specific SDG broken down by goal (Third row= first row+ second row). Information from this table used to create Figure 3.

SDGs	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
# of Papers	8	6	37	20	4	43	19	7	6	1	41	7	6	11	17	9	7

Table A 3- displays the frequency of SDGs across papers that focus on one SDG only (n=249).

	SDG_1	SDG_2	SDG_3	SDG_4	SDG_5	SDG_6	SDG_7	SDG_8	SDG_9	SDG_10	SDG_11	SDG_12	SDG_13	SDG_14	SDG_15	SDG_16	SDG_17
SDG_1	0.00	0.61	0.43	0.41	0.50	0.31	0.37	0.48	0.41	0.47	0.30	0.30	0.46	0.33	0.37	0.43	0.29
SDG_2	0.61	0.00	0.38	0.34	0.35	0.37	0.47	0.37	0.34	0.35	0.35	0.40	0.54	0.43	0.45	0.30	0.24
SDG_3	0.43	0.38	0.00	0.37	0.39	0.26	0.35	0.35	0.35	0.32	0.25	0.26	0.35	0.20	0.24	0.33	0.19
SDG_4	0.41	0.34	0.37	0.00	0.49	0.20	0.31	0.38	0.38	0.45	0.24	0.30	0.37	0.19	0.21	0.41	0.14
SDG_5	0.50	0.35	0.39	0.49	0.00	0.26	0.35	0.52	0.38	0.57	0.30	0.27	0.32	0.25	0.22	0.51	0.24
SDG_6	0.31	0.37	0.26	0.20	0.26	0.00	0.42	0.25	0.33	0.19	0.26	0.29	0.43	0.28	0.37	0.20	0.17

SDG_7	0.37	0.47	0.35	0.31	0.35	0.42	0.00	0.43	0.51	0.31	0.33	0.46	0.49	0.33	0.39	0.29	0.24
SDG_8	0.48	0.37	0.35	0.38	0.52	0.25	0.43	0.00	0.60	0.52	0.33	0.46	0.44	0.30	0.37	0.42	0.38
SDG_9	0.41	0.34	0.35	0.38	0.38	0.33	0.51	0.60	0.00	0.38	0.36	0.54	0.45	0.34	0.44	0.36	0.36
SDG_10	0.47	0.35	0.32	0.45	0.57	0.19	0.31	0.52	0.38	0.00	0.26	0.37	0.39	0.33	0.28	0.46	0.23
SDG_11	0.30	0.35	0.25	0.24	0.30	0.26	0.33	0.33	0.36	0.26	0.00	0.29	0.39	0.23	0.29	0.28	0.22
SDG_12	0.30	0.40	0.26	0.30	0.27	0.29	0.46	0.46	0.54	0.37	0.29	0.00	0.48	0.37	0.41	0.26	0.24
SDG_13	0.46	0.54	0.35	0.37	0.32	0.43	0.49	0.44	0.45	0.39	0.39	0.48	0.00	0.43	0.51	0.32	0.25
SDG_14	0.33	0.43	0.20	0.19	0.25	0.28	0.33	0.30	0.34	0.33	0.23	0.37	0.43	0.00	0.43	0.21	0.15
SDG_15	0.37	0.45	0.24	0.21	0.22	0.37	0.39	0.37	0.44	0.28	0.29	0.41	0.51	0.43	0.00	0.23	0.21
SDG_16	0.43	0.30	0.33	0.41	0.51	0.20	0.29	0.42	0.36	0.46	0.28	0.26	0.32	0.21	0.23	0.00	0.33
SDG_17	0.29	0.24	0.19	0.14	0.24	0.17	0.24	0.38	0.36	0.23	0.22	0.24	0.25	0.15	0.21	0.33	0.00

Table A 4- The table displays the correlation matrix of SDG pairs in the full dataset (n=690). The values range from 0 to 1 and demonstrate the rate of covariance between the 2 SDGs.

SDG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Global	127	132	143	127	117	146	132	129	125	115	140	128	129	121	133	116	113
MultiCountry/Regional	89	90	94	80	80	95	94	89	83	76	88	81	82	78	83	78	73
National	67	68	88	67	58	78	68	61	65	54	64	62	64	61	62	59	58
Local	69	73	76	71	59	83	62	67	63	61	93	61	67	55	76	61	56

Table A 5- This table shows the number of studies that lie within the 4 geographic scale categories broken down by SDG.

SDGs/ Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
2015	3	3	4	2	3	4	2	3	2	3	3	3	3	4	5	4	1
2016	3	3	4	6	4	3	3	3	3	3	6	2	3	3	2	4	3
2017	14	15	20	16	12	15	13	13	13	13	15	11	12	12	11	14	11
2018	34	36	37	31	28	41	35	33	26	29	33	29	30	31	30	28	26
2019	48	45	58	46	36	52	43	40	42	34	51	43	43	38	42	36	40
2020	108	115	122	109	101	132	116	114	110	99	117	106	110	94	110	103	96
2021	133	136	146	126	121	145	135	131	131	116	151	130	131	124	143	116	114
2022	9	10	10	9	9	10	9	9	9	9	9	8	10	9	11	9	9

Table A 6- This table demonstrates the breakdown of specific SDG related studies by year across 690 papers. Note that because papers can study more than one SDG, the total number of SDG studies in this table will be more than 690 even though only 690 papers were consulted. This table includes all years in the 2015-2022 even though 2022 was excluded in Figure 6.

Rank	SDG	Overall Frequency	Goal Specific Paper Frequency	PercentageALL	Percent Specific Goals
1	6	402	147	58.3	33.8
2	3	401	146	58.1	33.6
3	11	385	130	55.8	29.9
4	2	363	108	52.6	24.8
5	7	356	101	51.6	23.2
6	15	354	99	51.3	22.8
7	1	352	97	51.0	22.3
8	8	346	91	50.1	20.9
9	4	345	90	50.0	20.7
10	13	342	87	49.6	20.0
11	9	336	81	48.7	18.6
12	12	332	77	48.1	17.7
13	14	315	60	45.7	13.8
14	5	314	59	45.5	13.6
15	16	314	59	45.5	13.6
16	10	306	51	44.3	11.7
17	17	300	45	43.5	10.3

Table A 7- This table breakdowns the overall frequencies of SDGs evaluated across the 690 papers evaluated. The first column from the left ranks the SDGs in order from most to least cited in the literature, the second column lists the number of that SDG, third column the frequency out of all 690 papers, and the Percentage All Papers column denotes the overall number of papers that evaluate a certain goal over the total number of 690 papers evaluated for this portion of the study. The Goal Specific Papers Frequency denotes the number of papers that discuss that goal excluding the 255 all 17 SDGs evaluated papers. The Percent Specific Goals column denotes the number in the Goal Specific Paper Frequency over total number of papers excluding papers that evaluate all 17 SDGs (690- 255).

Word	**Frequency**
Australia	6
Earth observation	6
Education	6
impact	6
Land degradation	6
Monitoring	6
Peace	6
SDG 11	6
SDIs	6
Africa	7
Citizen science	7
developing countries	7

Development	7
Landsat	7
Synergy	7
UN SDGs	7
Education for Sustainable Development	8
Biodiversity	8
Energy	8
EU	8
Ghana	8
India	8
Indonesia	8
Inequality	8
interlinkages	8
Paris agreement	8
SDG 6	8
SDG indicators	8
Food security	9
governance	9
South Africa	9
Trade-off	9
MDGs	10
Sanitation	10
Sustainable tourism	10
tourism	10
COVID-19	11
Higher Education	11
RE	11
trade-offs	11
Network analysis	12
Poverty	12
synergies	12
Circular economy	13
United Nations	13
Water	13
Policy coherence	14
CSR	15
ES	15
Climate change	18

Agenda 2030	20
Indicators	23
2030 Agenda	26
Sustainability	67

Table A 8- Table is an extended version of Table 2. This table contains the all terms that were mentioned more than 5 times across the 699 paper dataset.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	52	46	44	44	47	49	52	50	46	48	42	44	45	49	38	42
2	57	0	46	46	45	52	57	55	51	46	52	46	48	49	51	39	44
3	49	46	0	45	43	47	48	44	42	42	44	43	45	43	44	37	39
4	50	46	46	0	44	45	48	46	45	44	44	44	45	42	43	39	41
5	48	44	43	42	0	44	44	44	44	42	44	43	42	43	43	36	38
6	51	51	46	44	44	0	55	45	45	41	49	45	47	46	45	36	39
7	53	52	48	46	44	51	0	50	47	42	46	46	46	46	46	37	40
8	56	51	45	45	44	46	51	0	51	48	48	44	45	47	50	39	45
9	56	53	44	45	45	47	50	53	0	45	49	50	47	46	48	40	44
10	52	46	42	43	42	42	43	48	44	0	44	41	44	45	45	41	42
11	54	48	45	44	44	46	48	50	48	45	0	44	46	46	47	39	41
12	47	46	42	41	41	46	47	45	49	39	44	0	42	44	43	34	37
13	57	52	51	50	47	45	55	52	52	49	53	48	0	50	51	44	46
14	53	52	44	42	43	49	49	50	49	45	48	46	45	0	50	40	40
15	54	52	44	41	41	46	51	53	48	43	51	43	48	48	0	37	41
16	43	38	36	36	34	37	37	38	38	38	38	34	37	38	37	0	34
17	47	42	37	37	35	39	39	46	42	38	39	36	38	38	39	33	0

Table A 9- This table contains matrix of studied interactions and the interaction totals used to create Figure 11. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	25	17	17	13	16	17	26	14	13	18	12	14	13	15	9	11
2	26	0	19	19	16	28	22	28	20	14	23	22	20	21	29	11	14
3	23	26	0	20	14	28	23	16	14	13	18	13	12	15	15	11	10
4	14	17	15	0	14	13	11	14	12	10	14	13	7	7	7	7	10
5	13	14	13	12	0	11	8	14	8	14	9	7	6	9	7	12	9
6	13	21	15	11	12	0	15	10	10	6	17	16	15	11	21	4	10
7	13	15	12	12	8	15	0	16	18	8	13	14	14	9	11	5	10
8	24	23	17	19	16	16	21	0	26	16	11	16	7	12	19	10	13
9	13	21	12	13	6	12	20	26	0	7	17	16	12	11	9	8	16
10	7	11	8	10	12	4	7	13	6	0	10	4	6	10	6	8	8
11	19	17	13	12	9	16	14	15	17	9	0	19	16	13	17	6	13

12	13	17	11	10	7	19	12	13	15	5	15	0	7	13	17	6	11
13	13	13	5	7	10	11	15	6	6	4	11	9	0	12	16	4	16
14	18	19	12	9	9	19	17	15	12	10	17	16	16	0	18	9	13
15	19	25	12	9	8	23	19	19	11	7	16	19	20	17	0	6	15
16	13	10	9	7	10	7	7	10	7	7	7	7	7	7	6	0	8
17	16	12	7	6	7	12	9	17	17	7	10	9	9	10	12	10	0

Table A 10- This table contains matrix of labeled significant interactions and the interaction totals used to create Figure 12. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	39	33	34	33	35	38	39	38	35	36	30	32	33	37	27	32
2	45	0	34	36	36	39	46	41	42	37	40	35	37	38	40	29	35
3	37	33	0	35	33	33	35	32	31	33	31	30	31	32	33	26	28
4	39	34	35	0	35	33	36	34	34	36	32	32	33	32	33	29	30
5	36	33	32	33	0	31	33	32	33	34	32	31	31	34	34	27	29
6	40	38	33	34	33	0	42	33	33	31	37	33	35	35	34	25	29
7	42	40	35	35	34	37	0	37	36	33	35	34	35	37	37	26	30
8	43	38	33	35	34	34	39	0	41	36	37	34	34	36	38	29	37
9	43	43	33	35	35	34	39	42	0	36	37	38	35	36	38	29	34
10	39	35	32	35	34	30	33	34	34	0	33	30	33	34	34	31	33
11	42	35	32	33	33	33	37	38	36	35	0	32	35	36	37	28	31
12	35	34	29	30	30	33	35	34	37	29	32	0	30	34	32	23	28
13	45	41	39	40	39	32	45	41	42	41	43	38	0	42	44	35	38
14	40	40	33	33	35	37	40	38	39	35	38	36	36	0	40	30	33
15	42	41	34	33	34	35	43	41	39	34	42	33	40	39	0	28	34
16	32	27	25	27	26	25	26	27	27	29	27	23	27	28	27	0	26
17	37	33	27	28	28	29	30	38	33	31	30	28	30	32	32	26	0

Table A 11- This table contains matrix of studied synergies (positive interactions) and the interaction totals used to create Figure 13. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	20	11	14	10	15	17	26	14	11	14	8	12	12	11	9	9
2	19	0	15	16	16	24	21	24	19	13	13	13	14	17	22	10	11
3	17	18	0	19	15	22	20	15	14	12	14	8	10	10	12	8	7
4	12	12	14	0	14	12	10	8	8	8	9	4	5	8	5	5	8
5	9	14	12	13	0	11	10	11	8	12	9	5	8	10	9	12	7
6	9	17	11	9	10	0	13	8	8	3	11	8	11	8	13	2	6
7	14	16	12	11	10	12	0	12	14	6	12	9	11	9	12	5	8
8	19	18	13	12	13	11	16	0	20	8	9	13	5	10	11	8	13
9	11	20	10	10	8	9	17	20	0	6	14	11	8	10	11	7	10
10	5	9	7	7	11	4	6	6	6	0	8	3	4	6	5	7	4
11	14	11	10	9	10	14	15	12	12	8	0	9	12	13	14	7	10
12	7	12	6	6	6	11	8	9	12	3	7	0	7	9	12	5	7
13	10	10	4	8	13	9	13	6	6	4	9	6	0	12	16	4	12
14	12	11	8	10	9	15	15	10	12	6	10	13	14	0	17	9	11
15	8	19	7	8	9	15	15	12	11	6	11	14	15	18	0	6	15
16	10	9	7	6	11	6	5	7	6	8	8	5	6	7	7	0	5
17	11	8	5	6	7	7	7	15	11	4	9	7	7	10	11	5	0

Table A 12- This table contains matrix of labeled significant synergies (positive interactions) and the interaction totals used to create Figure 14. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	34	28	28	28	29	30	34	32	30	30	25	27	29	33	26	27
2	40	0	28	30	29	34	38	39	34	31	35	31	31	34	35	27	30
3	31	27	0	26	26	28	27	26	24	25	25	27	26	27	27	24	24
4	33	28	27	0	29	26	27	30	27	29	26	28	28	28	27	27	27
5	31	26	25	27	0	27	25	27	26	26	26	27	24	27	26	23	23
6	34	33	28	27	28	0	36	28	28	26	32	28	31	31	30	25	25
7	35	33	28	27	27	32	0	31	29	26	28	30	27	30	29	24	25
8	39	35	28	31	29	29	32	0	35	34	31	28	28	32	35	27	30
9	38	35	26	28	28	29	31	36	0	29	31	34	29	30	31	27	29
10	35	29	25	27	26	25	25	32	27	0	27	25	27	29	28	28	28
11	36	30	26	27	27	28	29	31	30	29	0	27	28	29	30	26	25
12	30	30	26	27	26	28	30	28	33	24	27	0	24	28	27	22	21
13	33	26	25	26	23	27	27	28	27	26	28	25	0	26	27	24	24
14	37	36	28	29	28	33	32	34	32	30	31	30	28	0	34	27	26
15	39	36	28	27	26	31	34	38	32	28	35	28	32	33	0	25	28
16	31	25	23	25	22	25	24	25	25	26	25	22	24	25	24	0	23
17	33	28	23	25	22	25	25	31	28	26	24	21	23	25	26	23	0

Table A 13- This table contains matrix of studied tradeoffs (negative interactions) and the interaction totals used to create Figure 15. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0	0	4	2	2	1	1	3	2	2	0	5	2	4	4	2	1
2	1	0	1	4	1	3	8	4	4	1	9	8	4	7	8	1	2
3	2	3	0	3	1	1	2	4	1	2	4	5	1	4	3	2	2
4	3	4	2	0	4	2	6	7	5	3	4	9	5	3	5	5	3
5	4	1	2	4	0	3	1	4	3	2	2	5	1	3	2	3	2
6	4	4	2	3	2	0	8	4	2	1	6	5	6	3	4	3	2
7	3	5	2	4	1	3	0	7	4	2	2	8	2	3	7	2	2
8	6	5	4	6	4	8	7	0	5	9	1	5	4	8	10	2	3
9	2	2	1	4	2	5	2	4	0	2	4	7	5	3	4	0	3
10	3	1	2	1	2	1	3	8	1	0	1	3	2	5	2	0	2
11	0	3	1	2	1	1	1	2	3	1	0	4	0	3	1	0	1
12	6	5	4	7	5	6	8	8	6	3	3	0	0	2	3	3	3
13	4	3	1	4	1	3	2	3	3	1	1	2	0	0	1	0	3

14	7	10	3	3	3	4	7	10	7	4	5	2	3	0	4	2	1
15	10	10	4	5	2	4	10	12	5	2	5	3	5	2	0	1	2
16	2	0	2	4	2	3	2	2	0	0	1	3	1	2	1	0	2
17	2	2	2	3	2	2	2	3	3	2	1	3	2	1	2	2	0

Table A 14- This table contains matrix of labeled significant tradeoffs (negative interactions) and the interaction totals used to create Figure 16. Note that there are 0s for interactions of a goal with itself. This was not an aspect analyzed in our study as there was not enough data to breakdown interactions at the target or indicator level. The x-axis grey row of this table represents the influencing goals while the blue column represents the influenced goals.

	Influencing SDG 2	**Influencing SDG 6**	**Influencing SDG 7**
Influenced SDG 2	0	24	21
Influenced SDG 6	17	0	13
Influenced SDG 7	16	12	0

Table A 15- shows the reported significant positive interactions between the goals within the FEW Nexus. This data was used to create Figure 17.

	Influencing SDG 2	**Influencing SDG 6**	**Influencing SDG 7**
Influenced SDG 2	0	3	8
Influenced SDG 6	4	0	8
Influenced SDG 7	5	3	0

Table A 16 shows the reported significant negative interactions between the goals within the FEW Nexus. This data was used to create Figure 18.

	Organic Matter	Carbon	Nitrogen	Soil	Structure	Land	Energy	Water	Biome	Food	Nutrition	Crop	Biomass	Yield	Agriculture
Organic Matter	1.00	0.42	0.39	0.70	-0.01	0.28	0.13	0.12	0.17	0.10	0.02	0.51	0.38	0.19	0.09
Carbon	0.42	1.00	0.27	0.35	0.05	0.41	0.23	0.18	0.09	0.03	-0.02	0.41	0.21	0.24	0.01
Nitrogen	0.39	0.27	1.00	0.28	0.01	0.19	0.03	0.22	0.09	0.09	0.03	0.14	0.06	0.18	0.16
Soil	0.70	0.35	0.28	1.00	0.00	0.32	0.04	0.16	0.18	0.08	0.00	0.27	0.14	0.31	0.08
Structure	-0.01	0.05	0.01	0.00	1.00	0.02	0.07	0.09	-0.02	-0.08	-0.06	-0.04	0.02	-0.01	-0.05
Land	0.28	0.41	0.19	0.32	0.02	1.00	0.01	0.22	0.04	0.11	-0.02	0.50	0.10	0.31	0.12
Energy	0.13	0.23	0.03	0.04	0.07	0.01	1.00	0.17	-0.01	0.08	-0.04	0.14	0.35	0.12	0.05
Water	0.12	0.18	0.22	0.16	0.09	0.22	0.17	1.00	0.05	0.09	-0.03	0.12	0.06	0.18	0.06
Biome	0.17	0.09	0.09	0.18	-0.02	0.04	-0.01	0.05	1.00	0.02	0.00	0.04	0.02	0.10	0.01
Food	0.10	0.03	0.09	0.08	-0.08	0.11	0.08	0.09	0.02	1.00	0.17	0.22	0.06	0.24	0.39
Nutrition	0.02	-0.02	0.03	0.00	-0.06	-0.02	-0.04	-0.03	0.00	0.17	1.00	0.01	-0.01	0.06	0.17

Crop	0.51	0.41	0.14	0.27	-0.04	0.50	0.14	0.12	0.04	0.22	0.01	1.00	0.52	0.44	0.21
Biomass	0.38	0.21	0.06	0.14	0.02	0.10	0.35	0.06	0.02	0.06	-0.01	0.52	1.00	0.11	0.09
Yield	0.19	0.24	0.18	0.31	-0.01	0.31	0.12	0.18	0.10	0.24	0.06	0.44	0.11	1.00	0.23
Agriculture	0.09	0.01	0.16	0.08	-0.05	0.12	0.05	0.06	0.01	0.39	0.17	0.21	0.09	0.23	1.00

Table A 17 displays the correlation matrix for the rate of term use in SDG 2 frequency used to make Figure 23 (n=362). Positive numbers are associated with a positive correlation relationship (the use of this word increases the chance that the other word in pair will be present) while negative numbers are associated with less likelihood of the two terms being present in the same paper.

#1	sdg sustainable development goal	(KEY (sdg*) OR KEY (sustainable AND development AND goal*) AND TITLE (sustainable AND development AND goal*) OR TITLE (sdg*)) AND (EXCLUDE (PUBYEAR , 2023) OR EXCLUDE (PUBYEAR , 2022) OR EXCLUDE (PUBYEAR , 2014)) AND (EXCLUDE (PUBYEAR , 2013) OR EXCLUDE (PUBYEAR , 2012) OR EXCLUDE (PUBYEAR , 2011) OR EXCLUDE (PUBYEAR , 2010) OR EXCLUDE (PUBYEAR , 2009) OR EXCLUDE (PUBYEAR , 2008) OR EXCLUDE (PUBYEAR , 2007) OR EXCLUDE (PUBYEAR , 2006) OR EXCLUDE (PUBYEAR , 2005) OR EXCLUDE (PUBYEAR , 2004) OR EXCLUDE (PUBYEAR , 2003) OR EXCLUDE (PUBYEAR , 2001) OR EXCLUDE (PUBYEAR , 2000) OR EXCLUDE (PUBYEAR , 1999) OR EXCLUDE (PUBYEAR , 1998) OR EXCLUDE (PUBYEAR , 1995) OR EXCLUDE (PUBYEAR , 1993) OR EXCLUDE (PUBYEAR , 1992) OR EXCLUDE (PUBYEAR , 1984)) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) View Less ^ Edit query	1,899

Table A 18 shows the exact search inquiry used on SCOPUS database to find articles downloaded on January, 4th, 2022. KEY= keywords and TITLE = article title.