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Mapping publications by Sustainable Development Goal at the faculty level to highlight inter-faculty collaborations.

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Please accept this manuscript titled, *Mapping publications by Sustainable Development Goal at the faculty level to highlight inter-faculty collaborations*, for consideration for publication in the International Journal of Sustainability in Higher Education.

We believe this submission would be suited to your journal's scope of interest as it focuses on how HEIs are engaging in the SDGs across (and between) disciplines. Importantly, we provide an automated methodology for HEIs to track SDG-related publications, analyze current interdisciplinary publications, and identify potential interdisciplinary research collaborations.

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Thank you in advance for your consideration and feedback.

Mapping publications by Sustainable Development Goal at the faculty level to highlight inter-faculty collaborations.

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Statements and Declarations

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Author 1: Conceptualization, Methodology, Software, Data curation, Writing – original draft.
Author 2: Conceptualization, Methodology, Software, Data curation, Writing – original draft.
Author 3: Conceptualization and Writing – original draft.

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Abstract

Purpose:

Achieving the United Nations' Sustainable Development Goals requires partnerships across nations, sectors, and stakeholders. In academia, interdisciplinary research can help to address complex challenges related to the Goals. This paper offers a structured approach to identifying current and potential research collaborations across faculties at a Canadian university.

Design:

Publications from the Dimensions database that had been assigned to an SDG category were matched against publications indexed by the university's Research Information Management System. The

resulting matches were then sorted and tabulated by ANZSRC research category and by the faculty affiliation of the authors. Potential interdisciplinary research collaborations are then identified by matching authors from different faculties who both have publications within the same research category.

Findings:

Findings demonstrate that institutions can apply this methodology to track SDG-related publications, to analyze current interdisciplinary publications, and to identify potential interdisciplinary collaborations. Since 2018, 95% of McMaster University's SDG-related publications are authored by a researcher or researchers from a single faculty and 5% are authored by researchers from two or more faculties. The interdisciplinary research collaborations were found to have a lower average citation impact and alternative metric scores than those publications with authors from a single faculty. Using a test case, 28 researchers from two faculties were identified as having common research interests with the potential to collaborate on a specific sustainability-related topic. Leveraging this methodology and an institution's RIMS system provides university leaders with insight to track progress and plan research activities across the institution.

Originality:

The analysis methods followed in this study highlight the importance of interdisciplinary research collaborations and may be valuable to institutions wanting to benchmark their own SDG efforts. Moreover, a simple methodology is presented for re-combining the data on prior collaborations to identify opportunities for new collaborations between faculties. This process combines the power of data processing the user's contextual insights to uncover novel pairings of faculty members whose research is aligned.

Keywords

Sustainable Development Goals, interdisciplinary research, research partnerships, interdisciplinary collaboration, bibliometrics, higher education

Introduction

Advancing the United Nations Sustainable Development Goals (UN SDGs) is a focus of many research institutions of higher education. An important theme in the discussion around how universities can work towards these goals is the need for an interdisciplinary approach, as the complex solutions to the challenges of sustainable development require a combination of expertise found in different departments and faculties:

> "The 17 Sustainable Development Goals highlight the grand challenges for global society and are intertwined, with progress in one affecting progress in all others. With this starting point, we argue that interdisciplinary research is the way to achieve them. Accordingly, we need to overcome the conceptual and structural challenges that can hinder it." (Herzig Van Wees, 2019)

This suggests a more thorough re-imagining of the organizational structure of the university. Rather than simply pursuing interdisciplinary research within the current faculties, a re-alignment of programs that bring together researchers from different faculties is seen as a more effective way of approaching

the multidimensionality of the SDGs. An example of this is provided by the University of Helsinki which adopted a more interdisciplinary structure by combining researchers from six faculties under the umbrella of the *Helsinki Institute of Sustainability Science*, underlining that "…building the structures for sustainability research and education requires the breaking down of existing disciplinary silos." (Kaisa Korhonen-Kurki, 2019). A similar effort in Germany seeks to foster SDG-related research by transcending both faculty and institutional boundaries. In order to adapt their institutions to meeting the sustainability challenges, sixteen universities in North Rhine-Westphalia (under the consortial name "RWTH") are engaged in structural transformations through the joint sustainability "Humboldt^{n}" initiative:

> "[A] future-oriented university needs to be particularly agile [in order to address] the SDGs... RWTH therefore has pooled its scientific expertise in an interdisciplinary research environment of eight cross-faculty profile areas to work on solving the great social challenges of our time…. Cooperation between various scientific disciplines, meaning the interdisciplinary collaboration of researchers on technological, ecological, social, and economic levels, plays a crucial role." (Höhl, 2024)

While most universities will not attempt such ambitious re-organization, these examples highlight how inter-faculty collaborations are seen as the best way of doing research that aligns with the UN's sustainable development goals.

This also has implications for the university's role in training the experts of tomorrow. From a pedagogical perspective, the need for interdisciplinary solutions to the complex questions posed by the sustainable development goals means that universities should encourage collaborations that transcend the faculty structure of the institution:

> "Complex problems addressed by the Sustainable Development Goals (SDGs), such as climate change, rising inequality and entrenched poverty, are interconnected and hence call for collaborative approaches and integrated solutions. Traditional monodisciplinary educational approaches do not adequately prepare students to develop innovative solutions to address the SDGs." (Stubbs, 2021)

Fostering a more collaborative approach to higher education is already being pursued at universities worldwide, with institutions in Poland (Podgórska, 2024) and Australia (Stubbs, 2021) combining researchers from a range of faculties to co-design a curriculum that better addresses the interconnected issues in sustainability than would teaching approaches considered SDGs from a single perspective.

In order to better manage this shift towards more inter-faculty collaborations, institutions need to be able to track these initiatives. However, few resources exist to enable a university's administration to do this, with university rankings offering only comparisons at a global level. For example, the Times Higher Education (THE) consultancy has highlighted the role of SDGs in academia by providing 'Impact Rankings', which, starting in 2019, rank institutions by their research output as defined by the SDGs (Times Higher Education, 2022). This provides some context in which universities can benchmark their efforts against other institutions. Across all Impact Rankings criteria, McMaster rated 93.1, and is ranked ninth in Canada and 37th in the world in 2022. Part of THE's methodology includes evaluating universities' research output that is linked to SDGs. While useful to assess and promote an institution's SDG-related research publications overall, the Impact Rankings cannot provide details at the faculty or departmental level. A more granular view of an institution's research at the level of

faculties and departments would provide the university's leadership with insights into the strengths and weaknesses within the institution in terms of each SDG. This would allow the institution to be more strategic when planning future research, including fostering collaborations between faculties.

Previous attempts by universities to establish a baseline of their SDG activities are rare, but a project by Yale University in 2017-2018 offers a glimpse into the difficulty in capturing such output without using a computational approach to handle the relevant metadata. Goodall and Moore (Goodall & Moore, 2019) describe how five students were employed over the course of a year and a half to manually comb through the online profiles of Yale's faculty members, deciding on a subjective basis whether each individual's research aligned with any of the 17 Goals. While the dedication of that university in seeing such a project to completion should be applauded, it also highlights the inefficiency and limitations of collecting data by looking at webpages. First, in addition to being listed on their personal webpage, each of the research articles produced by a faculty member is also indexed in various bibliographic databases that are freely searchable at the Yale Library. A short consultation with a Librarian would have produced a formatted list of such publications, saving countless hours of manual labor. Moreover, as the project made no attempt to assign the publications found into the various SDG categories, the result is simply a subjective binary yes/no assessment of the faculty member's relatedness to the general concept of sustainable development. As just about any research could be said to relate in some way to one of the 17 Goals, this project offers Yale's administration few details to act upon.

A better approach to obtaining an overview of SDG-related-research is to use bibliometric metadata as indexed in several databases of academic publications (such as Web of Science, Scopus, and Dimensions). However, information about the organizational structure of the university is beyond the scope of a database of publications. This is instead the purpose of a university's *Research Information Management System* (RIMS), which provides a public-facing profile of each faculty member's research, organized by departmental affiliation. By matching the organizational affiliations of faculty members with the bibliographic metadata of their publications, a detailed picture of the strengths and weaknesses of the university in terms of SDGs can be obtained at the level of faculties and departments. This approach makes it possible to identify publications with authors from different faculties in order to highlight the interdisciplinarity of SDG research.

Interdisciplinary collaborations are valued because they are seen to produce more innovative and high-quality research (National Academy of Sciences, 2005). It has been found that creative approaches that cross disciplinary boundaries are more effective at producing new knowledge (Shneiderman, 2016, p. 336). Indeed, studies have shown that such interdisciplinary research is more highly cited (Chen *et al.*, 2015), even if it may come at the cost of decreased productivity due to overcoming the "language barrier" when collaborating across specialties (Leahey *et al.*, 2017). According to Abramo *et al.* (2017), interdisciplinary research publications have shown greater rates of citation in at least a third of the cases analyzed, with even greater citation impact for specific interdisciplinary research – that is, a research collaboration between sectors that have favourable synergy, such as Mathematics and Computer Sciences.

Despite this, such research faces an uphill battle in that interdisciplinarity is (by definition) at odds with the university's siloed organizational structure of faculties and departments that each have their own priorities and goals (Arnold *et al.*, 2021, Fam et al., 2019). More specifically, Sá (2008) identifies

the "transactional costs" that come with conducting interdisciplinary research are often *"...related to the organizational context of universities, such as resource allocation and credit systems that do not fund and/or reward individuals and units for crosscutting collaborations; evaluation, promotion, and tenure processes that do not properly evaluate or undervalue collaborative and interdisciplinary work; and departmental and campus cultures and climates that are indifferent or hostile to such activities*."

For Arnold *et al.* (2021), the engagement across the university that underpins the success of interdisciplinary projects should combine the bottom-up interests of researchers with the top-down goals of the administration. These authors report on the lessons learned from the *Flagship Constellations Initiative* of the University of Mississippi. This provided infrastructure, funding, and networking for faculty members to come together to collaborate in four pre-defined topic areas (forming "constellations" of researchers). Emphasizing an approach informed by community-based participatory research principles, Arnold *et al*. provide recommendations arising from the Constellations Initiative. These include incorporating support for interdisciplinarity in professional development, tenure and promotion guidelines, and strategic planning.

Most relevant to this study, they recommend that the university establish "Multidisciplinary Research Databases" to shift the culture of the university away from working in silos by helping researchers identify interdisciplinary research opportunities. This is exactly the purpose of the programmatic approach detailed in this study. It should serve as a tool to facilitate the conversations that are required to build a culture of interdisciplinary collaboration. In conjunction with the lessons learned from the Constellations Initiative, McMaster University could use the analytical approach described here to pair individuals according to their shared interests.

The objective of this article is to present a bibliographic research methodology to identify and analyze current and potential research collaborations across faculties at an institution of higher education. Significantly, the purpose of this study is not only retrospective. To make this information actionable by the university's leadership, opportunities for future inter-faculty collaborations are also identified. Authors who are affiliated with different faculties but whose publications are in the same SDG category and the same research topic are highlighted. While the focus of this study has been on publications related to the UN SDGs, findings are applicable to institutions interested in identifying current and potential interdisciplinary research collaborations on other topics of interest.

Methods

The dataset includes three types of publications: *Research Article*, *Review Article*, and *Conference Paper* with at least one co-author from McMaster University. In theory, all publication types could have been considered, but this implies a mixing of publication characteristics that would have complicated the interpretation of the data. For example, although the production of preprints has grown considerably since the COVID pandemic, these were not considered as they have not passed peer-review. The three publication types selected have comparable characteristics and cover the vast majority of research output. Also, as their timeline to publication is much shorter than monographs, they are more representative of the current research interests of a given faculty. While it is true that journals in different fields have different characteristics, this study only compares collaborations as grouped at the level of SDGs and faculties, so is not affected by journal-level features.

The records retrieved covered publications from January 1st, 2018 to December 31st, 2023 (the 'study period') that contribute to one or more SDGs. While originally conceived as a five year study to end in 2022, project delays allowed for the addition of the most recent full year (2023), which fortuitously provides for the most up-to-date snapshot of the research output of each faculty.

This research sources information from the Dimensions citation database at dimensions.ai. Following consideration of other databases, including Scopus and Web of Science, the Dimensions database was chosen for the following reasons:

1. Metadata is added to publication listings based on their association to one or more Sustainable Development Goals (Jackson, 2020). This provides a definitive and repeatable categorization of publications by SDG.
2. Availability of Research Citation Ratio, Field Citation Ratio, and Altmetric attention score, which can be used to quantify the impact of publications across fields.

The following five steps outline our process of data collection and analysis. Associated findings of each step are presented in the Results section. Detailed steps necessary to replicate these results, including all data and queries, are provided in the Supplementary Material found in a Figshare repository (Demaine et al., 2024; doi.org/10.6084/m9.figshare.25075727.v1).

Step 1. Overview and comparison to global output

The initial step of this research was to identify all SDG-related publications by all researchers at McMaster during the study period. Conveniently, Dimensions assigns publication records to one or more of 16 SDGs as described by Jackson (2020). It is important to note that although Dimensions allows authors to self-identify if their research is related to SDG 17 (Partnerships for the Goals), Dimensions does not index SDG 17 publications in the same way as it does for other SDGs because Goal 17 is an SDG about other SDGs. As such, SDG 17 was excluded from this investigation. A comparison of the global output of SDG-related publications to McMaster's is provided in the Results section.

Step 2. SDG publications by faculty

To identify which faculty or faculties are associated with each publication retrieved from Dimensions, records were augmented with their authors' faculty affiliation by matching the DOIs of the publication metadata against the publication records held in the university's *Research Information Management System* (RIMS). McMaster's RIMS is built upon the *Symplectic Elements* system (version 6.11), a product of Digital Science. The public-facing view of this RIMS is called "McMaster Experts" (McMaster University, 2023). Note that it is just as easy to identify the individual's departmental affiliation, but that level of detail was not necessary for this analysis. As a result of this matching process, it is possible to count which documents by which faculty correspond to which SDG.

Step 3. Multi-faculty collaboration patterns

While the concept of interdisciplinary research can be defined in many ways, such as the collaboration of different departments within a faculty or the collaboration of researchers with unique specializations within the same department, for the purposes of this study, "interdisciplinarity" is defined as the

connection between different faculties. This is to acquire a broader view of interdisciplinary research, as any findings at a broad level will likely translate well to a narrower level.

To gain a general understanding of the collaboration patterns between faculties, pivot tables were generated from the records described in Step 1 to identify those multi-faculty collaborations that produced the greatest number of SDG-related publications. First, a table of faculty-faculty collaborations for all SDG-related publications with two more contributing researchers was produced.

Step 5. Impact analysis

The metadata retrieved from Dimensions includes metrics for each publication. Along with the count of *Times Cited*, in this study we consider the impact of publications as expressed by:

- Altmetrics are "… complementary to traditional, citation-based metrics. They can include… peer reviews on Faculty Opinions, citations on Wikipedia and in public policy documents, discussions on research blogs, mainstream media coverage, bookmarks on reference managers like Mendeley, and mentions on social networks such as Twitter." (Raymond et al., 2015)
- Field Citation Ratio (FCR) is "…a citation-based measure of scientific influence of one or more articles. It is calculated by dividing the number of citations a paper has received by the average number received by documents published in the same year and in the same Fields of Research (FoR) category… [A] publication with an FCR of 1.0 has received exactly the same number of citations as the average, while a paper with an FCR of 2.0 has received twice as many citations as the average for the Fields of Research code(s). (Dimensions, 2022)".

The average for each of these metrics was determined in each SDG category for publications involving one and multiple (two or three) faculties.

Step 4. Exploration of the topics for potential collaborations

The next step was to identify specific researchers who have the potential to collaborate, based on their research interests. The primary challenge during this step was to determine a set of criteria for which to focus the scope of analysis. The breadth of topics associated with the 16 SDGs are plentiful and range from gerontology to circuit theory and to transportation geography. Too many publications would not be feasible to assess manually, while too few would not provide sufficient evidence or number of researchers from across campus. Scoping by SDG was too broad. Scoping by keyword was too specific.

In addition to categorizing publications by SDGs, Dimensions also lists publications according to several other ontologies. To further refine the results, *Australian and New Zealand Standard Research Classification* (ANZSRC 2020) "Fields of Research" categories were included as part of the metadata for each record (Australian Bureau of Statistics, 2020). The ANZSRC is a hierarchy of 1,754 specific research *Fields* organized into 190 broader *Groups* that are in turn collected into 23 general-research *Divisions*. These take the form of two-digit Divisions (e.g. "34 Chemical Sciences"), four-digit Groups (e.g. "3402 Inorganic Chemistry"), and six-digit Field codes (e.g. "340206 Metal Cluster Chemistry") of increasing specificity. Dimensions assigns ANZSRC codes to publications at the Groups and Divisions levels.

To identify potential research collaborations, a table listing the researchers name, faculty, ANZSRC category (group or division), SDG, DOI, and keywords was compiled with each of the 8,594 publications from the study period. Those related to SDG 7 and with authorship by experts from Science and Engineering were thought to be a reasonable starting point for analysis.

Results and Discussion

Overview

The Dimensions database lists a total of 32,605 publications produced by McMaster researchers during the study period. Of these, 25,406 records could be matched by DOI to an individual in the McMaster Experts Research Information Management System (RIMS). Of these, 8,594 had also been assigned to an SDG category by Dimensions. The breakdown of these figures by year is shown in Figure 1. It is encouraging to note the increasing coverage of McMaster's RIMS system in proportion to the total number of publications. While the number of matched articles in the RIMS (blue columns) has declined slightly since 2021, it has actually increased as a proportion of all publications (grey columns). As faculty members become more knowledgeable about the advantages of publishing with ORCIDs and in curating their online profiles, the automated matching of articles with their respective authors in the local RIMS system (i.e. the ratio of the blue columns to the grey columns) has increased from 67.8% in 2018 to 82.2% in 2023.

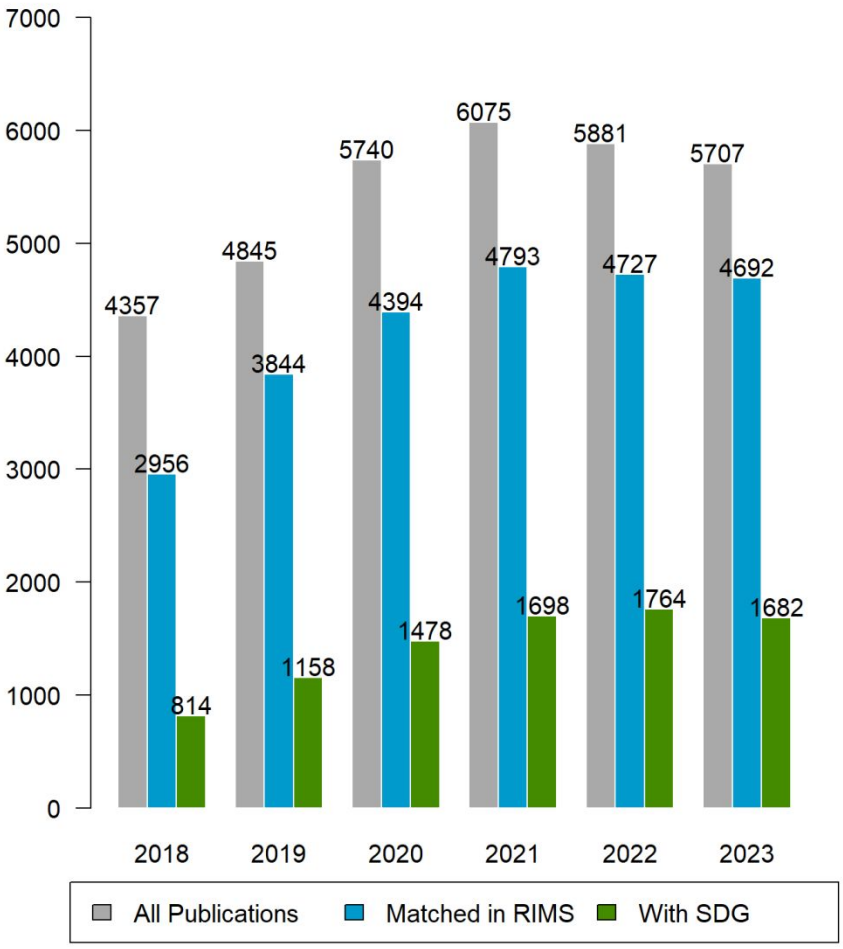

Figure 1. McMaster University publications by year

Comparison to global output

In comparison to the global output across the SDG categories in the five years covered by this study, the distribution of publications from McMaster researchers is highly skewed towards SDG 3 - Good Health and Well Being (compare the "*percentage of Global/ McMaster output*" columns in Table 1). The 8,474 publications in this category (before matching with Experts records) represent 72.5% of McMaster's output, nearly double the global concentration, reflecting the university's expertise in the Health Sciences field. Across the 16 other categories, McMaster's proportion of publications is much lower. Only in the field of Gender Equality (SDG 5) is the output in line with global patterns at 1.3% (see Table 1).

SDG	*Global Publications*	*% Global output*	*McMaster Publications*	*% McMaster output*
1 No Poverty	29,147	0.4%	18	0.2%
2 Zero Hunger	289,075	3.8%	138	1.2%
3 Good Health and Well Being	2,966,200	38.6%	8,474	72.5%
4 Quality Education	750,971	9.8%	722	6.2%
5 Gender Equality	110,254	1.4%	152	1.3%
6 Clean Water and Sanitation	69,326	0.9%	88	0.8%

7 Affordable and Clean Energy	1,263,248	16.4%	958	8.2%
8 Decent Work and Economic Growth	150,031	2.0%	90	0.8%
9 Industry, Innovation and Infrastructure	129,474	1.7%	69	0.6%
10 Reduced Inequalities	104,856	1.4%	62	0.5%
11 Sustainable Cities and Communities	213,248	2.8%	89	0.8%
12 Responsible Consumption and Production	131,959	1.7%	39	0.3%
13 Climate Action	445,995	5.8%	291	2.5%
14 Life Below Water	177,705	2.3%	64	0.5%
15 Life on Land	315,981	4.1%	164	1.4%
16 Peace, Justice and Strong Institutions	524,812	6.8%	261	2.2%
17 Partnerships for the Goals	7,962	0.1%	16	0.1%
Total	**7,680,244**		**11,695**	

Table 1. McMaster University publications by SDG (2018-2023), compared to global output.

SDG publications by faculty

Because a publication may be about multiple SDGs as well as being authored by researchers from different faculties, the 8,594 publications map to the 9,345 categorizations-by-affiliations in Table 2. Within this grand total are many instances of publications involving two or more faculties.

The distribution by faculty is highly skewed, with the Faculty of Health Sciences producing 6,588 publications (70.5% of McMaster's total output). Of these, 88.7% address SDG *#3 - Good Health and Well Being*. A distant second place is the Faculty of Engineering with 1,179 publications (12.6% of total output), most of which (725; 61.5%) fall into Goal *#7- Affordable and Clean Energy*.

SDG	*Health Sciences*	*Engineering*	*Science*	*Social Sciences*	*Business*	*Humanities*	*Total*
1 No Poverty	5	1	2	5	1	1	**15**
2 Zero Hunger	54	11	31	8	4	1	**109**
3 Good Health and Well Being	5,845	175	427	222	68	17	**6,754**
4 Quality Education	446	18	27	39	15	25	**570**
5 Gender Equality	54	2	6	34	10	3	**109**
6 Clean Water and Sanitation	9	28	29	3	1		**70**
7 Affordable and Clean Energy	9	725	89		3		**826**
8 Decent Work and Economic Growth	10	1	9	35	11	1	**67**
9 Industry, Innovation and Infrastructure	1	31	1		19		**52**
10 Reduced Inequalities	10	1	9	19	4	1	**44**
11 Sustainable Cities and Communities	22	25	16	5	7		**75**
12 Responsible Consumption and Production	2	19	2		8		**31**
13 Climate Action	8	111	115	8	5		**247**
14 Life Below Water	5	4	42	2	2		**55**
15 Life on Land	2	22	97	4		2	**127**
16 Peace, Justice and Strong Institutions	97	4	12	31	14	22	**180**
17 Partnerships for the Goals	9	1	1			3	**14**
Total	**6,588**	**1,179**	**915**	**415**	**172**	**76**	**9,345**

Table 2. SDG publications by faculty. As some publications are assigned more than one SDG, totals by row and column are greater than the number of distinct publications.

Multi-faculty collaboration patterns

To-tease out the patterns of collaboration within the 9,345 categorizations and affiliations, the publications were split into those involving only one faculty, and those resulting from inter-faculty collaborations. Again, because some publications correspond to more than one SDG, the 8,594 publications affiliated with a faculty member in McMaster Experts were assigned to 8,919 SDG categories by Dimensions (that is, 325 publications were assigned to two or more SDG categories). Of these, 8,432 (94.5%) were produced by a single faculty. Only 487 (5.5%) were the result of a collaboration between two or three faculties (see Table 3).

- ***Good Health and Well Being***: Of the 6,420 publications related to SDG 3, 6,064 (94.5%) were produced by a single faculty. Only 356 (5.5%) involved researchers from two or three faculties. The greatest number of these collaborations brought together researchers from the faculties of Science and of Health Sciences.
- ***Quality Education***: Among all 540 publications related to SDG 4, a total of 503 (93.1%) were written by researchers from within the same faculty, and 37 publications (6.8%) involved researchers from two or three faculties. These were sprinkled across a range of collaborators, mostly involving the Faculty of Health Sciences.

- ***Affordable and Clean Energy***: Among all 815 publications related to SDG 7, a total of 787 (96.5%) were the result of single-faculty research, with only 28 (3.4%) bringing together researchers from two or three faculties. Interestingly, all but two involved the faculties of Engineering and Science.

SDG	Matched in RIMS	Single Faculty				Two+ Faculty			
		Pubs.	Times Cited	FCR	Altm. Attn.	Pubs.	Times Cited	FCR	Altm. Attn.
1 No Poverty	10	6	5	4.5	4.6	4	10	4.8	11.7
2 Zero Hunger	103	97	25.2	11.9	38	6	2.2	0.4	20.2
3 Good Health and Well Being	6,420	6,064	23.2	12.3	58.7	356	14.3	6.9	60.5
4 Quality Education	540	503	11.7	6.8	15.9	37	5.2	4.3	12.1
5 Gender Equality	106	99	18	15.2	39.4	7	7.9	3.3	5
6 Clean Water and Sanitation	66	61	13.3	5.1	10.8	5	2.8	0.7	1
7 Affordable and Clean Energy	815	787	19.3	6.8	21.7	28	21.6	5.5	22.8
8 Decent Work and Economic Growth	63	59	9.7	5.4	16.6	4	4.5	5.7	7
9 Industry, Innovation and Infrastructure	52	50	31.8	20.8	3	2	12	9.6	1
10 Reduced Inequalities	43	41	14.6	10.2	53.2	2	5	4.8	5.5
11 Sustainable Cities and Communities	66	56	10.9	6.8	8	10	11	6.8	4.3
12 Responsible Consumption and Production	29	27	29.4	3.7	214.5	2	2	0.3	4.5
13 Climate Action	238	223	24.4	6.4	45.3	15	30.3	5.8	173.1
14 Life Below Water	55	55	15	6	41.2				
15 Life on Land	123	119	26.7	8	31.1	4	9.3	8.7	3.7
16 Peace, Justice and Strong Institutions	178	175	7.7	5.5	22.8	3	2.3		10.5
17 Partnerships for the Goals	12	10	19.7	10.9	14.1	2	15.5	8.6	17.5
Total	**8,919**	**8,432**				**487**			
Average			*18*	*8.6*	*37.6*		*9.7*	*5.1*	*22.5*

Table 3. Comparing the average of Times Cited, Altmetric attention score, and Field Citation Ratio (FCR) by SDG, for publications from one and two (or more) faculties. Note that publications can be assigned to more than one faculty.

As presented in Table 4, the greatest number of inter-faculty collaborations involve the faculties of Health Sciences and Science (179), followed by the faculties of Health Sciences and of Social Sciences (96), and then by the faculties of Health Sciences and of Engineering (83). These findings are expected, given the large number of SDG-related publications by the faculties of Health Sciences, Engineering, and Science respectively.

Impact analysis

As the FCR is a normalized metric of research impact, the global average is one (1). This simplifies the evaluation of the relative impact of research across different fields. Table 3 shows that McMaster's publications have an FCR greater than one for all SDGs, signifying that the research being performed is above average across all fields.

In almost all cases, publications from a single faculty received more citations and captured more Altmetric attention than did research in the same SDG involving two or three-faculties (see Table 3). Similarly, the Field Citation Ratio (FCR) is greater for collaborations within a single faculty. For publications involving one faculty the average is 8.6, whereas collaborations between faculties have an FCR of 5.1.

		Sustainable Development Goal																	
Faculty	*Collaborator*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*Total*
Health Sciences	Science	1	3	156	13	1			1			3				1			**179**
Health Sciences	Social Sciences	3		80	5	3	1				2	1					1		**96**
Health Sciences	Engineering	1	3	71	3							1	2				1	1	**83**
Science	Engineering			14	3		4	21						8		3			**53**
Science	Social Sciences	1		17	1							1		4					**24**
Health Sciences	Business			18	3														**21**
Social Sciences	Business			7	5				3			1					1		**17**
Engineering	Business			1				1		1		3		3					**9**
Health Sciences	Humanities			2	3													1	**6**
Science	Humanities			3	1														**4**
Engineering	Humanities			2	1														**3**
Science	Business			1	1														**2**
Social Sciences	Engineering			2															**2**
Social Sciences	Humanities			1	1														**2**
	Total	**6**	**6**	**375**	**40**	**4**	**5**	**22**	**4**	**1**	**2**	**10**	**2**	**15**	**0**	**4**	**3**	**2**	**501**

Table 4. Collaborations between two or three faculties by SDG. Note that a publication may be assigned more than one SDG.

Exploration of the topics for potential collaborations

Given this list of publications that have been matched to SDGs and ANZSRC field of research, how might the university identify potential research collaborations that cross disciplinary boundaries? Using this list in an SQL query to create pairs of faculty members, the metadata of past publications can be re-purposed as a tool for planning new research. Potential co-authors are identified where the SDG and Field of Research match, but where the authors' faculty affiliations are different. To ensure that only new collaborations are identified, the pairs of authors who have appeared in previous publications are excluded. Because such a large proportion of McMaster's publications are categorized as SDG 3, for practical purposes the matching was limited to the 16 other SDGs. The result is 8,571 pairs of authors, along with their respective departmental and faculty affiliations, who have not already collaborated, but who have the potential to do so (see Figure 2).

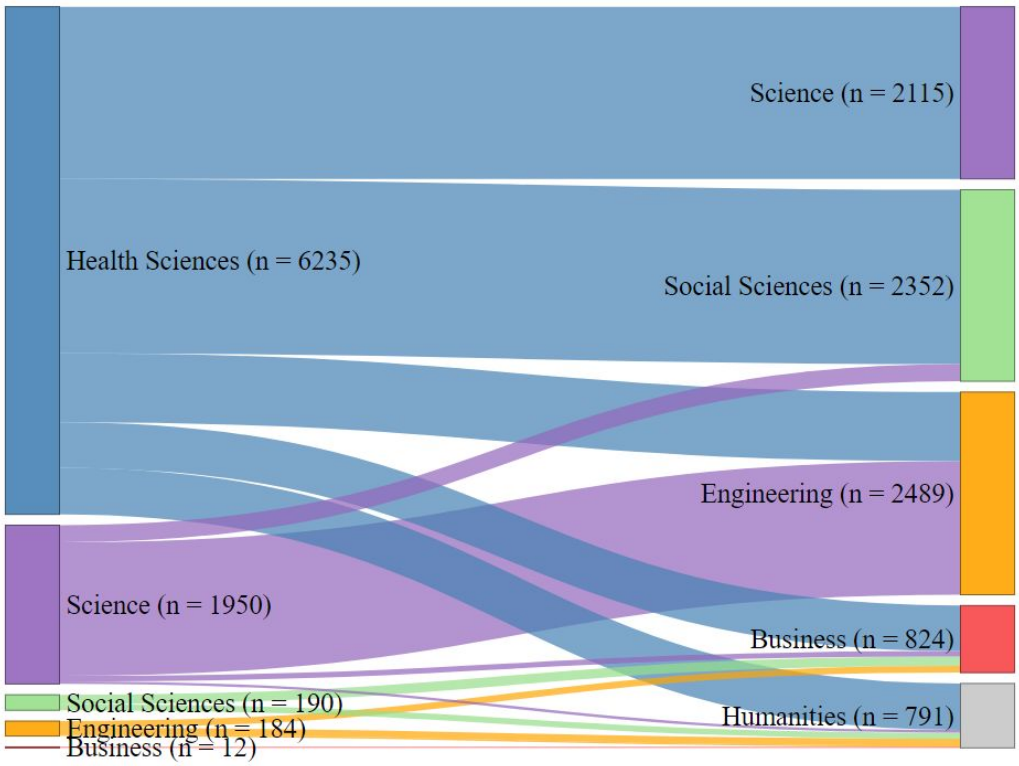

Figure 2. Potential collaborations between faculties by matching authors by SDG (excluding SDG 3) and ANZSRC field of research.

Example of finding collaborators

The following example illustrates how this table of paired authors can be used. Consider a case in which the Research Office has identified a new grant opportunity for interdisciplinary research on the topic of "sustainable transportation". How might the university identify faculty members around which a grant application could be based?

The list of 17,142 distinct faculty members (i.e. double the number of 8,571 pairs of authors) can be filtered by criteria relevant to the hypothetical grant opportunity. In this case, the SDGs 7 ("Affordable and Clean Energy") and 11 ("Sustainable Cities and Communities") were selected. By themselves, these SDGs are far too broad to identify the topic of sustainable transportation. But a manageable set of results can be arrived at by leveraging the ANZSRC fields of research, which offer a more granular classification of publications. Three relevant fields were chosen:

- 3304 Urban and Regional Planning
- 3509 Transportation, Logistics and Supply Chains
- 4011 Environmental Engineering

Finally, as the goal is to identify interdisciplinary collaborations, two different faculties are selected. For this example, the faculties of *Engineering* and *Science* are likely to be the most relevant.

The resulting list of matches reveals 19 people from the Faculty of Engineering and 9 from the Faculty of Science whose research would seem to be aligned. Rather than presenting management with a spreadsheet of names, the relationships between potential co-authors can be visualized as a network. In

Figure 4, those associated with the Faculty of Engineering are represented by orange nodes, and those in Science by purple nodes:

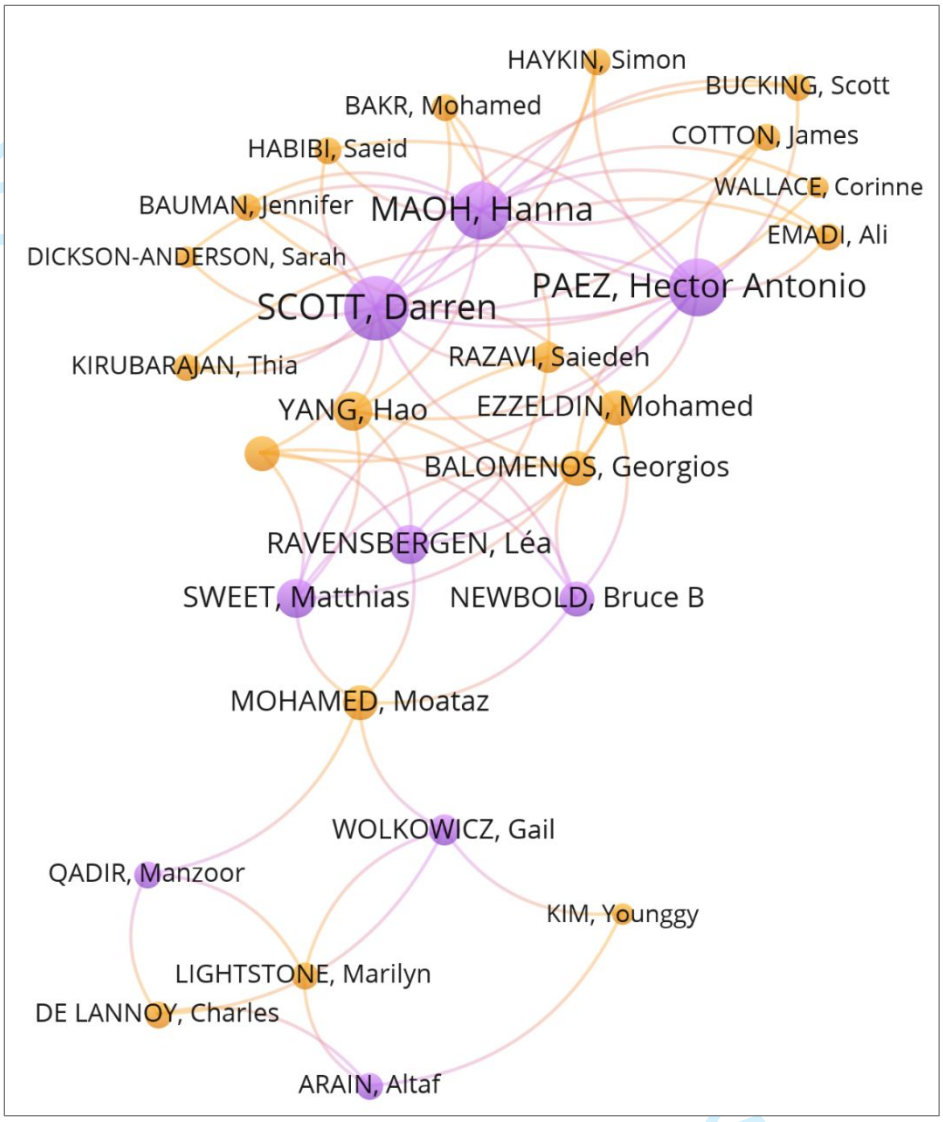

Figure 3. Potential new co-authors on the topic of "sustainable transportation" from the faculties of Engineering (orange) and Science (purple).

At this stage, the manipulation of metadata and sorting of spreadsheets reaches its limits. From this point, the expertise and judgement of managers much be relied on to read the published research and to infer relationships. The similarities illustrated in Figure 3 suggest which researchers one might consider. At the top of the network, many people from the Faculty of Engineering cluster around *Darren Scott, Hector Antonio Paez*, and *Hanna Maoh*. Consulting the McMaster Experts RIMS, a sample of *Hanna Maoh*'s publications illustrates how his research aligns well with the hypothetical grant opportunity:

> "Battery electric vehicle acquisition timeframes in Canadian fleets" (*Transportation Planning and Technology*)
>
> "Examining the Variability of Crossing Times for Canadian Trucks at the Three Major Canada–U.S. Border Crossings" (*Professional Geographer*)

In order to make this an inter-faculty collaboration, a researcher from the Faculty of Engineering is selected for comparison. *Saiedeh Razavi* is located nearby *Maoh* in the network, and it seems clear that their research is indeed similar:

> "Adoption patterns of autonomous technologies in Logistics: evidence for Niagara Region." (*Transportation Letters*)
>
> "Transportation data visualization with a focus on freight: a literature review" (*Transportation Planning and Technology*)

Thus, by combining techniques to manipulate the metadata with the interpretation of textual meaning, a process is arrived at that successfully identified two researchers who, despite not having co-authored together, seem to be publishing on a similar topic. This alignment suggests that they would be ideal collaborators on which a grant proposal could be based.

This example illustrates how the leadership of the university can, by selecting a few criteria and then performing a quick scan of the paired authors' publications, arrive at new insights into the untapped potential collaborations that exist across campus. Once the metadata has been compiled, no particular technical skills are required to identify matching authors based on common research interests. It is straightforward to create a dashboard that would provide a user-friendly interface, allowing managers to filter the data with a few clicks.

A positive outcome is that through manual analysis, an interdisciplinary group of researchers have been identified as having common research interests, and who could be encouraged to explore new collaborations. While there were gaps in the data, the automation of even the partial dataset made the process of finding relevant articles for further analysis straightforward. While there was still a level of manual analysis involved, it was of a reasonable amount.

Limitations and Future Directions

There are limitations associated with each step of the methodology and/or how the results are shared.

Other potential databases

While other publication databases could have been used for this investigation, Dimensions was chosen because it had robust metadata added to publication listings based on their association to one or more Sustainable Development Goals and because of the availability of Field Citation Ratio and Altmetric data. While using another database, such as Scopus, would produce slightly different results, the relative number of publications by faculty or by SDG would remain similar.

Faculty members lacking profiles in Experts

Of the 32,605 publications from 2018 to 2023 from McMaster found in Dimensions, 25,406 (80%) could be matched against the publication lists in faculty members' profiles in McMaster Experts. This determined how accurate the departmental and faculty affiliations could be ascertained. While there are organizational reasons why the remaining 20% of publications were not matched (e.g. an adjunct appointment may not justify the creation of an Experts profile), the underlying issue is that some faculty members have left their Experts profiles untended. While the Library assigns staff to maintain these profiles, it is really the responsibility of individuals to curate their own profiles. This need not be

an administrative chore: a faculty member can link their Experts profile with their ORCID, Scopus, and Web of Science author profiles, such that the RIMS system is automatically updated when new publications appear.

That being said, an 80% compliance rate is very high and shows how McMaster's RIMS system is functioning as intended: Once faculty members assert their identity by claiming their profiles, the RIMS system can automatically ingest their publications. While a richer network of collaborations could have been derived from the remaining 7,199 publications had more faculty members taken charge of their research profiles, it is unlikely the added precision would have resulted in a qualitatively different analysis. No database of publications will index the entirety of the academic literature, and no RIMS system will ever be 100% up to date. Even without perfect information, the process described here produced insights into topics of common interest that would otherwise be hidden, allowing the university's leadership to make decisions about future research. This illustrates both the value of using a RIMS system, and how the metadata it contains can be used by a university to better understand its own research activity at the level of departments and faculties.

Review of interdisciplinary research collaborations

When assessing publications to determine the level of interdisciplinary collaborations involved, only faculties of McMaster University were considered. For example, if a publication included two authors from McMaster's Faculty of Science and a third author from University of Toronto's Faculty of Engineering, it would not have been identified as interdisciplinary. Through manual analysis, this level of assessment can and would be valuable to pursue. However, without access to a database of all universities' researchers and their respective faculty associations, this level of automated assessment is not possible.

Interdisciplinarity at the faculty level

The division of "research disciplines" is arbitrary. At McMaster, there are six faculties, each containing dozens of departments. Arguably, research collaborations involving researchers in different departments within the same faculty could also be considered "interdisciplinary". At that level of granularity, the results of this study would differ: more faculty members would be matched on common topics of interest, but finding those who were not already co-authors would be more difficult. The advantage of the programmatic approach detailed here is that finding such matches at scale would be trivial: simply by adjusting a few queries results would be obtained in minutes. Note that while McMaster has its own list of faculty divisions, they are not necessarily the same as other universities, making comparisons between institutions more complex. In that situation there may be better ways of defining disciplinary divisions that are independent of any institution's organizational structure.

Exploration of current and potential research collaborations

In our manual assessment, topic areas were defined by the available research categories in Dimensions. These may or may not align with how researchers define their areas of research focus. Furthermore, the SDG-specific tags within the Dimensions metadata might not facilitate interdisciplinary collaborations that span beyond traditional disciplinary bounds. Using the example mentioned in the Introduction section, a political scientist in the Faculty of Social Sciences might focus on policy related to environmental impact on land and have valuable contributions to make regarding appropriate

regulations for implementation of a clean technology being investigated by an electrical engineer. This potential connection may be too abstract to be captured by simply matching on SDGs and research categories. The technique described here provides a way of leveraging the metadata to support decision making, but it is only through the insights and expertise of the decision maker that connections can be made.

Discussion and Future Research

Not only does the complexity of sustainable development call for more interdisciplinary research, but as the incubators of the ideas of tomorrow, universities are called on to re-combine their faculties to be more cross-disciplinary so as to be more effective in conducting SDG-related research. Beyond simply being examples of the multidisciplinarity that SDG-focused research requires, inter-faculty collaborations are the testbed for how the university might be better structured to engage in sustainability issues, both in terms of the design of the curriculum it offers and of the research it pursues. The technique presented in this study shows how bibliometric metadata, when combined with information on faculty membership, can reveal successful inter-faculty collaborations and offer insights into which researchers might produce new sustainability-related research.

In this project, the publications from McMaster University were categorized by their alignment with the UN's Sustainable Development Goals as well as by the faculty affiliation of the authors. In contrast to similar projects that have sought to characterize a university's output by SDG, the programmatic approach detailed here offers several advantages. Key takeaways of the relevance of this study in terms of the management of higher education:

1. The contributions of McMaster researchers in achieving SDG targets are highlighted. This report can serve as a baseline for the institution in measuring its progress towards those goals.
2. Shows the use of a RIMS to support the strategic planning of a university. The purpose of a RIMS is not simply to provide the same look-and-feel for professors' web pages. Instead, by combining information about the organizational structure of the university with the teaching activities and publication records of individuals, a RIMS such as McMaster *Experts* provides university leadership with a tool for understanding the research expertise across the institution.
3. Specifically, this study shows how a RIMS system can be leveraged to provide insights into the interdisciplinarity of research at the departmental and faculty level.
4. Provides a baseline against which progress towards more interdisciplinary research can be gauged.
5. Provides impetus for more faculty members to curate their McMaster Experts profiles. If the university's goal is to foster interdisciplinary collaboration and SDG-aligned research, this study underlines the importance of keeping faculty members' profiles up to date.

Yet fostering interdisciplinary research cannot be achieved simply through data analysis. As emphasized by Arnold *et al.* (2021), successful large-scale collaborations are the result of both top-down initiatives and bottom-up engagement to bring about a community-based cultural change at the university. In conjunction with the recommendations arising from the *Constellations Initiative* of the

University of Mississippi, the data-driven approach described here can support the university's drive to both encourage more research into SDGs in conjunction with more collaborations.

While this study focusses on SDGs, it serves more broadly as an example of how the Library can support its institution's strategic planning efforts. By leveraging the metadata in the bibliometric databases to which the Library subscribes, and by linking it to profiles in the university's RIMS, the intersection of research fields and departmental structure can be uncovered. This approach could be applied to examine other facets of the university's published output. For example, comparing departments by their adoption of Open Access publishing, or the proportion of industry collaborations by departments. Moreover, as this is a largely automated process, this analysis can be repeated on an annual basis, thus becoming a regular part of how the institution benchmarks improves its progress.

The real value of this type of study lies not in the numbers, but in the questions and conversations it might generate among the university's leadership. By fostering such introspection, this analysis provides a tool to inform administrative decision-making. The authors hope that this report serves as the first step in employing recursive investigations into how McMaster is performing and to facilitate important discussions among university leaders and researchers across the institution.

Supplemental Materials

All methods and data are available in the Figshare repository:
https://doi.org/10.6084/m9.figshare.25075727.v1

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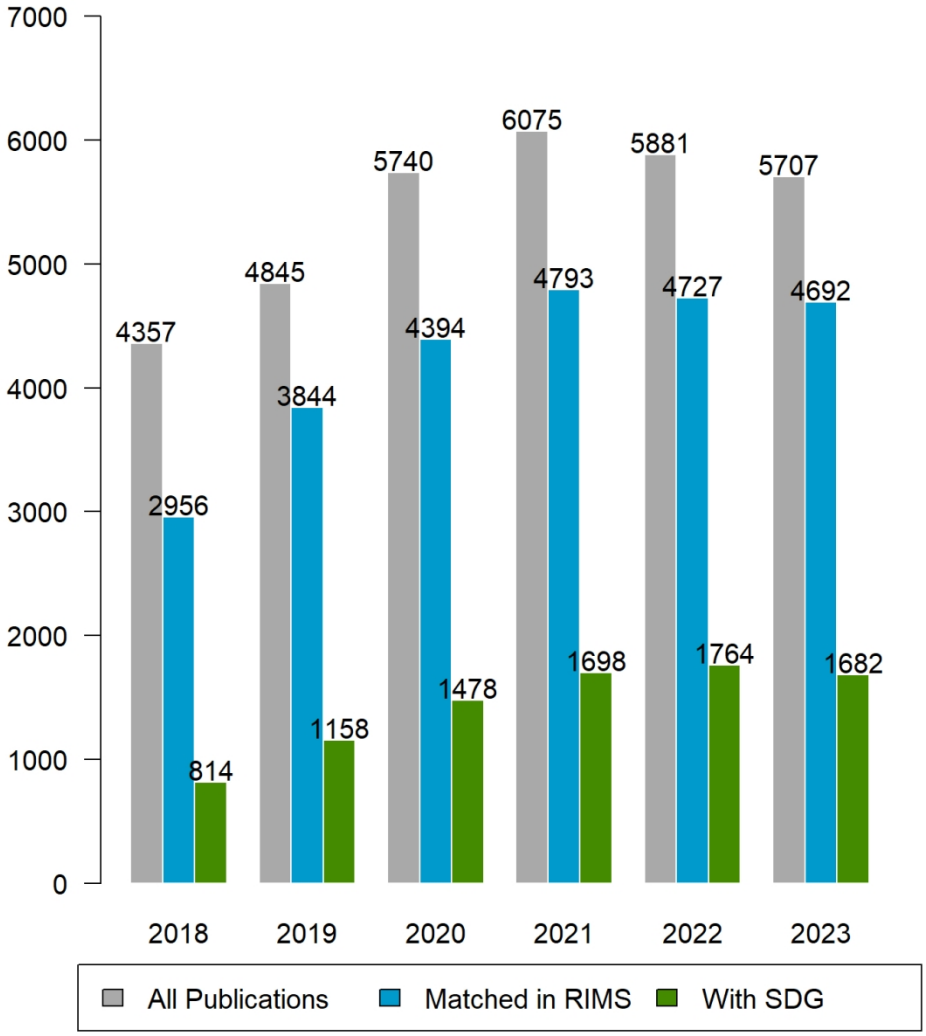

Figure 1. McMaster University publications by year

392x417mm (94 x 94 DPI)

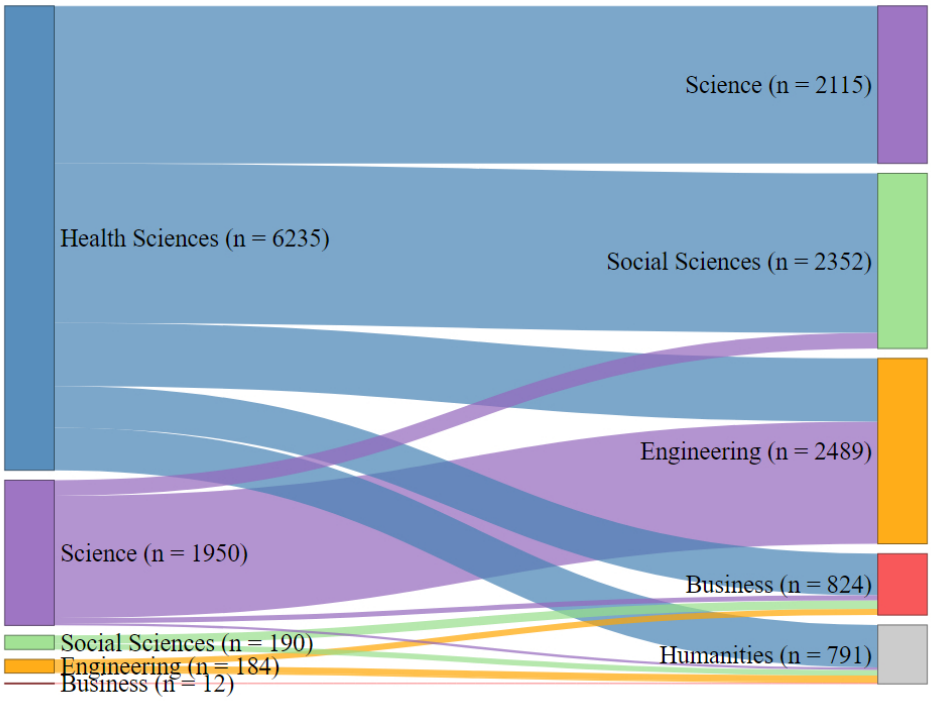

Figure 2. Potential collaborations between faculties by matching authors by SDG (excluding SDG 3) and ANZSRC field of research.

349x262mm (72 x 72 DPI)

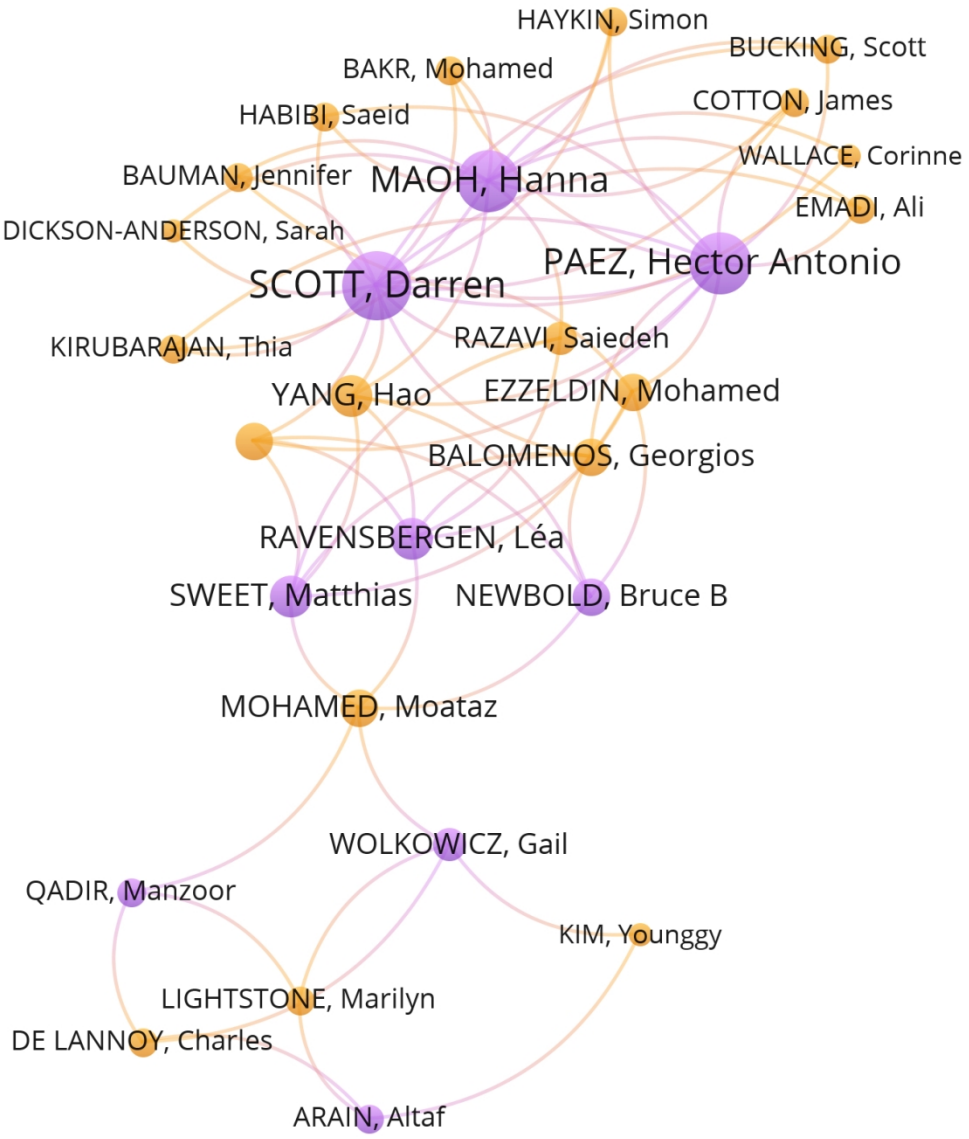

Figure 3. Potential new co-authors on the topic of "sustainable transportation" from the faculties of Engineering (orange) and Science (purple).

470x558mm (75 x 75 DPI)

SDG	*Global Publications*	*% Global output*	*McMaster Publications*	*% McMaster output*
1 No Poverty	29,147	0.4%	18	0.2%
2 Zero Hunger	289,075	3.8%	138	1.2%
3 Good Health and Well Being	2,966,200	38.6%	8,474	72.5%
4 Quality Education	750,971	9.8%	722	6.2%
5 Gender Equality	110,254	1.4%	152	1.3%
6 Clean Water and Sanitation	69,326	0.9%	88	0.8%
7 Affordable and Clean Energy	1,263,248	16.4%	958	8.2%
8 Decent Work and Economic Growth	150,031	2.0%	90	0.8%
9 Industry, Innovation and Infrastructure	129,474	1.7%	69	0.6%
10 Reduced Inequalities	104,856	1.4%	62	0.5%
11 Sustainable Cities and Communities	213,248	2.8%	89	0.8%
12 Responsible Consumption and Production	131,959	1.7%	39	0.3%
13 Climate Action	445,995	5.8%	291	2.5%
14 Life Below Water	177,705	2.3%	64	0.5%
15 Life on Land	315,981	4.1%	164	1.4%
16 Peace, Justice and Strong Institutions	524,812	6.8%	261	2.2%
17 Partnerships for the Goals	7,962	0.1%	16	0.1%
Total	**7,680,244**		**11,695**	

SDG	*Health Sciences*	*Engineering*	*Science*	*Social Sciences*	*Business*	*Humanities*	*Total*
1 No Poverty	5	1	2	5	1	1	**15**
2 Zero Hunger	54	11	31	8	4	1	**109**
3 Good Health and Well Being	5,845	175	427	222	68	17	**6,754**
4 Quality Education	446	18	27	39	15	25	**570**
5 Gender Equality	54	2	6	34	10	3	**109**
6 Clean Water and Sanitation	9	28	29	3	1		**70**
7 Affordable and Clean Energy	9	725	89		3		**826**
8 Decent Work and Economic Growth	10	1	9	35	11	1	**67**
9 Industry, Innovation and Infrastructure	1	31	1		19		**52**
10 Reduced Inequalities	10	1	9	19	4	1	**44**
11 Sustainable Cities and Communities	22	25	16	5	7		**75**
12 Responsible Consumption and Production	2	19	2		8		**31**
13 Climate Action	8	111	115	8	5		**247**
14 Life Below Water	5	4	42	2	2		**55**
15 Life on Land	2	22	97	4		2	**127**
16 Peace, Justice and Strong Institutions	97	4	12	31	14	22	**180**
17 Partnerships for the Goals	9	1	1			3	**14**
Total	**6,588**	**1,179**	**915**	**415**	**172**	**76**	**9,345**

SDG	Matched in RIMS	Single Faculty				Two+ Faculty			
		Pubs.	Times Cited	FCR	Altm. Attn.	Pubs.	Times Cited	FCR	Altm. Attn.
1 No Poverty	10	6	5	4.5	4.6	4	10	4.8	11.7
2 Zero Hunger	103	97	25.2	11.9	38	6	2.2	0.4	20.2
3 Good Health and Well Being	6,420	6,064	23.2	12.3	58.7	356	14.3	6.9	60.5
4 Quality Education	540	503	11.7	6.8	15.9	37	5.2	4.3	12.1
5 Gender Equality	106	99	18	15.2	39.4	7	7.9	3.3	5
6 Clean Water and Sanitation	66	61	13.3	5.1	10.8	5	2.8	0.7	1
7 Affordable and Clean Energy	815	787	19.3	6.8	21.7	28	21.6	5.5	22.8
8 Decent Work and Economic Growth	63	59	9.7	5.4	16.6	4	4.5	5.7	7
9 Industry, Innovation and Infrastructure	52	50	31.8	20.8	3	2	12	9.6	1
10 Reduced Inequalities	43	41	14.6	10.2	53.2	2	5	4.8	5.5
11 Sustainable Cities and Communities	66	56	10.9	6.8	8	10	11	6.8	4.3
12 Responsible Consumption and Production	29	27	29.4	3.7	214.5	2	2	0.3	4.5
13 Climate Action	238	223	24.4	6.4	45.3	15	30.3	5.8	173.1
14 Life Below Water	55	55	15	6	41.2				
15 Life on Land	123	119	26.7	8	31.1	4	9.3	8.7	3.7
16 Peace, Justice and Strong Institutions	178	175	7.7	5.5	22.8	3	2.3		10.5
17 Partnerships for the Goals	12	10	19.7	10.9	14.1	2	15.5	8.6	17.5
Total	**8,919**	**8,432**				**487**			
Average			*18*	*8.6*	*37.6*		*9.7*	*5.1*	*22.5*

		Sustainable Development Goal																	
Faculty	***Collaborated with***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***	***17***	***Total***
Health Sciences	Science	1	3	156	13	1			1			3				1			**179**
Health Sciences	Social Sciences	3		80	5	3	1				2	1					1		**96**
Health Sciences	Engineering	1	3	71	3							1	2				1	1	**83**
Science	Engineering			14	3		4	21						8		3			**53**
Science	Social Sciences	1		17	1							1		4					**24**
Health Sciences	Business			18	3														**21**
Social Sciences	Business			7	5				3			1					1		**17**
Engineering	Business			1				1		1		3		3					**9**
Health Sciences	Humanities			2	3													1	**6**
Science	Humanities			3	1														**4**
Engineering	Humanities			2	1														**3**
Science	Business			1	1														**2**
Social Sciences	Engineering			2															**2**
Social Sciences	Humanities			1	1														**2**
	Total	**6**	**6**	**375**	**40**	**4**	**5**	**22**	**4**	**1**	**2**	**10**	**2**	**15**	**0**	**4**	**3**	**2**	**501**