Deliverable 3.1

PACE-NET Plus State-of-the-Art: "Bibliometric analyses on Pacific-EU scientific cooperation"

Pacific-Europe Network for Science, Technology and Innovation

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This report uses Scopus Custom Data 1996-2013 (Partial Year)

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Executive Summary

As part of the PACE-Net Plus project's monitoring and updating of information of Pacific-European (EU) Science, Technology and Innovation (ST&I) collaboration, this report provides bibliometric analyses using Scopus data of Pacific publications and co-authorship patterns over the period 1996-2013 (partial year). It also then provides an analysis of potential collaboration between Europe and the Pacific that could occur in the three EU societal challenge areas of 1) health, demographic change and wellbeing; 2) food security, sustainable agriculture, marine and maritime research and the bio-economy; and 3) climate action, the environment, resource efficiency, and raw materials.

Analyses find that Pacific Island Countries and Territories (PICTs) have 7341 publications referenced in the Scopus database over the study period. Approximately a third of these are in the domains of the aforementioned societal challenges (2) and (3) and 20% relate to societal challenge (1). The remainder are on other topics. Papua New Guinea, New Caledonia and Fiji produce the largest numbers of PICT publications with over 1500 publications each. PICTs also have high levels of co-authorship with countries including France (especially with New Caledonia and French Polynesia), Australia (especially with Papua New Guinea, Fiji and to a lesser extent New Caledonia) and the USA (especially with Papua New Guinea, Guam and to a lesser extent with New Caledonia and French Polynesia). The United Kingdom also co-publishes with Papua New Guinea at a similar level to these lesser relationships.

By using topic modelling on these publications and matching these results to the societal challenge areas, over 1.4 million similar European (and Australian and New Zealand) publications were extracted from the Scopus database, with approximately 45% found challenge (1), 35% in challenge (2) and 20% in challenge (3). Further analyses of these publications showed that the United Kingdom and Germany consistently published the highest numbers of relevant publications across all three areas, followed by France and Italy. Co-publishing relationships showed that Australia and New Zealand have strong additional research collaborations in these areas that do not always include a PICT co-author, as well as many that do. Despite its research strength, Germany had surprisingly few strong institutional-level relationships with any PICTs.

It is concluded that although there are large mismatches of scale between numbers of Pacific and European researchers (and institutions) working and publishing on Pacific-relevant issues in these societal challenges, there is strong potential for enhancing existing relationships (e.g. between France, the UK and PICTs) and developing new ones. These might be facilitated by using “brokering” partners such as Australia, New Zealand, France or the UK, which have existing cultural understanding and working collaborative relationships, to develop new multi-lateral research partnerships. Such a mechanism is likely to lead to greater volumes and quality of research quicker than individual EU countries building new relationships with PICTs from scratch.

Table of Contents

Project Overview

PACE-Net Plus is the **Pacific-Europe Network for Science, Technology and Innovation**. Considering the results of past and ongoing initiatives supporting European Union (EU) - Pacific Science Technology and Innovation (ST&I) cooperation, the main objectives of PACE-Net Plus include: supporting the EU-Pacific policy dialogue in ST&I, reinforcing the EU-Pacific ST&I cooperation, bridging the gap between public and private sectors, and strengthening the Pacific-EU research cooperation partnerships.

Financed by the European Commission under the Seventh Framework Programme (FP7), the project consortium includes 16 partners from the Pacific region and the EU.

For more information on the PACE-Net Plus project, please consult the website: www.pacenet.eu.

1 Report Background

An objective of the PACE-Net Plus project is to monitor and update information of Pacific-European (EU) Science, Technology and Innovation (ST&I) collaboration. This follows on from the "State-of-the-Art" work that was carried out under the predecessor project "PACE-Net" from 2010-2013.

Under the PACE-Net project, a desktop study of Pacific policy documents was carried out to identify priority areas in the region for development and research, and a questionnaire for both administrators of research organisations and individual researchers was developed and administered, across the Pacific region, with most responses emanating from the (South) Pacific Island Countries and Overseas Countries and Territories (of which the collective grouping of both is given the acronym "PICTs" – Pacific Islands Countries and Territories). Reports and a computerised database of a number of scientific projects in the region, developed by the University of the South Pacific (USP), emanated from this work (see http://old.pacenet.eu for further details).

The PACE-Net Plus project seeks to extend but not duplicate this initial State-of-the-Art work, and build on the lessons learnt from the PACE-Net project. Specifically, it was recognised in the PACE-Net project that the size and capacity of organisations across the

Pacific region is particularly variable, including the resources they have at their disposal to respond to surveys and/or query their data-bases for projects, publications or other activities, as was required for the questionnaire administered in the PACE-Net project.

PACE-Net Plus has therefore decided to undertake a multi-method state-of-the-art analysis, in order to attempt to overcome this issue. For example, rather than relying just on questionnaires and individual's responses, other data available in external databases, such as those on internationally recognised scientific publications, is used. This helps to expand the reach of the project's analyses, beyond close networks of contacts or those readily accessible following internet searches.

The analysis has also been more targeted based on the thematic interests of the project which relate to three "societal challenges" of the European Union's Horizon2020 research and innovation framework program (http://ec.europa.eu/programmes/horizon2020/):

- Challenge 1: health, demographic change and wellbeing;
- Challenge 2: food security, sustainable agriculture, marine and maritime research and the bio-economy; and
- Challenge 5: climate action, the environment, resource efficiency, and raw materials

The methods used in the "multi-method" analysis included:

- Interviews and/or written questionnaires to gather data on ST&I policies, priorities, projects and EU cooperation from Pacific region policy-makers, and research and education institution and innovation organisation representatives (see Deliverable no. 2.1)
- Desktop review work (including internet trawling) to gather:
    - Additional data on EU-Pacific cooperation activities such as previous participation in European Commission funded projects (used in the development of Deliverable no. 2.1); and
    - Information on individual Pacific Island Countries and Territories including general statistics, constitutional structures and research institutions that can be used by European or other researchers interested in working in the Pacific (see Deliverable 1.1).
- Bibliometric analyses to look at some of the recent scientific work emanating from the PICTs as well as current collaboration patterns and potential for greater EU-Pacific challenges. This is the focus of this Deliverable no. 3.1;

- Data stemming from thematic think-tank workshops, specifically about EU-Pacific cooperation, which will be used to supplement other data sources in Deliverable no. 2.1.

Inquiries were also made about patent data through IP Australia, but there were only 10 patents lodged from Pacific Island Countries and Territories (5 public), so analyses of innovation and research on that base was not continued. Questions specific to innovation in the Pacific were instead developed into a separate interview guide by UNIDO (see Deliverable no. 4.1), and further research on this basis could be carried out in the future by contacting the World Intellectual Property Office (WIPO) to see whether and how many Pacific patents are lodged in other countries.

The rest of this report is dedicated to the bibliometric analyses.

2 Introduction: Pacific-EU bibliometric analyses

Bibliometrics are statistical analyses carried out on large sets of publication data. They can be used to find patterns in publication rates based on attributes of interest that are available in the data-base, such as by author, institution, country, year, publication name (i.e. journal), title, abstract, key-words or topic area (often know as a "Field of Reseach"). Collaboration patterns can also be investigated by looking at co-authored papers, that is where a number of researchers from different institutions publish one collective paper.

Bibliometrics can be a useful tool for supporting policy-making at institutional, national or other levels related to science and innovation policy, so there are many data analysts and researchers who regularly publish their bibliometric analyses or produce them for policy-makers direct use.

The work carried out for the PACE-Net Plus project by the ANU uses the SCOPUS publication database (Scopus Custom Data 1996-2013 (2013 partial year): see www.scopus.com for further information), and draws upon data analysis techniques and knowledge previously used to support the Australian Government's Office of the Chief Scientist (e.g. Office of the Chief Scientist, 2012) and the Australian-EU collaboration patterns investigated by the FEAST EU project (e.g. Matthews et al., 2009).

The bibliometric analyses presented in this report seek not to replicate the FEAST work but instead place a strong focus on Pacific Islands Countries and Territories' publications, collaboration patterns and current thematic capabilities, rather than Australia, New Zealand or the EU, since there are other EC funded bi-lateral projects that could focus on updating these collaboration patterns.

The methodology is presented in the next section, which is used to investigate: 1) recent PICT publications and collaboration patterns; and 2) potential future collaboration with the EU under the previously mentioned societal challenges.

3 Methodology

With the two aforementioned objectives on investigating current PICT publications and then future potential collaborations, the methodology used was carried out in two main stages.

3.1 Stage 1: Extracting Pacific Island Country and Territory publications and collaboration patterns

The first stage of the methodology was to extract all publications from the SCOPUS database that had at least one PICT author. This was taken as having the "country" field of the institutional affiliation of an author as one of the PICTs. All of these 7341 extracted publications were then sorted under their "country" affiliation(s) to determine publication volumes per PICT. Collaboration patterns between countries were also investigated by looking at the "country" field of other authors on the same papers, and these pairs of country labels totalled to determine collaboration volumes. Visualisations of this data at the country level used the capital city coordinates of each PICT or other nation as the geographical locator of the country volume and start point for collaboration volume markings. Institutional level volumes and collaborations are shown are localised according to the city field given in the institutional affiliation. All of the results from this stage are presented in Sections 4.1.

3.2 Stage 2: Determining EU collaboration potential with the Pacific under the societal challenge areas

The second stage of the methodology required more complex methods to determine collaboration potential between the Pacific and the EU under the societal challenge areas. Although there were a few different methodologies that could have been employed, it was decided that maintaining a strong focus on current Pacific capacity and research interest in the societal areas of interest would form a useful base for determining similar EU strengths and research interests. In the conclusions and perspectives section, alternative methods that could be used to further strengthen the analyses are provided.

For the purposes of this study, a topic model was developed using the first set of 7341 Pacific publications, augmented by another 4651 distinct publications from around the world that focussed on Pacific-related topics or issues. These were found through a search of the keywords and title text fields using the terms presented in Appendix 1, which were mostly Pacific country or territory names. The topic modelling system "MALLET" (http://mallet.cs.umass.edu) was then used on this set of 11992 publications. A range of topic model scenarios with between 10 and 100 topics was run with both random and fixed seeds to determine what granularity and diversity of topic areas would be most relevant for the EU paper search.

At the same time, an analysis of the three EU societal challenges of focus in the PACE-Net Plus project was undertaken to determine important subthemes and keywords for each of these. Descriptions on the Horizon2020 website, as well as reviews of current calls under these themes and additional words from PACE-Net Plus partners to cover Pacific-related issues, were then used to populate the keyword field for each of these subthemes. The results of this analysis are presented in Appendix 2.

Once this analysis had been completed, the outputs of the topic model were analysed against these subthemes and keywords to determine an appropriate number of topics that would adequately cover all of these subthemes. This resulted in the topic model run with 60 topics being selected. 52 of these topics were then assigned to specific subthemes. The remaining 8 topics were not fit into any of the societal challenges as they were outside the scope of interest or too general (e.g. names of countries or research/data collection methods).

The topic models allocated to each of the subthemes were then used to extract European and Australian/New Zealand publications from the Scopus database. This yielded a total of 1,419,752 publications.

Similar analyses and visualisation techniques to look at volumes by country or institution origin, patterns of collaboration and thematic areas of competence were then carried out as explained in Section 3.1. The results from these analyses are presented in Section 4.2.

4 Results

4.1 Pacific Island Country and Territory publications and collaboration patterns

Analyses of the 7341 Pacific Island Country and Territory publications from the Scopus database show that Papua New Guinean, New Caledonian and Fijian authors produce the largest numbers of publications of the PICTs (see Figure 1a, Figure 1b, Figure 2 and Table 1) with over 1500 publications each. Authors from French Polynesia and Guam then produce the next largest outputs with between 500 and 1000 publications. This is followed by the Solomon Islands, Vanuatu, Samoa, the Federated States of Micronesia and Palau (see Figure 1a, Figure 1b, Figure 2 and Table 1) with over 100 publications in the database from 1996-2013. Authors from other PICTs have participated in or produced minimal numbers of publications, although there is some annual variation (see Figure 2).

However, what is also seen is that large numbers of these PICT publications are co-authored with authors from other countries. For example, Australia, the USA and France, each counts over 1300 publications, which due to our methodological selection are thus all co-authored with at least one PICT author (see Figure 1a and Table 1). Other countries that have significant co-authoring relationships with PICTs are the United Kingdom and New Zealand with approximately 500 publications each in the period of analysis (see Table 1). A number of important, but more moderate, co-authoring relationships exist with Germany, Italy, Spain, Switzerland, India, Japan and Canada (with over 100 publications each as shown in Figure 1a).

The largest co-authoring partnerships are shown in Figure 1a and Table 2. Perhaps unsurprising considering historical ties, the partnerships with the largest volumes of co-publication are France with New Caledonia, Australia with Papua New Guinea and France with French Polynesia (over 500). Australia and Fiji also co-publish significant numbers of articles (457 in the study period). The USA also has a number of strong co-publishing partnerships with PICTs and Australia and France, as does Australia with New Caledonia and the United Kingdom with Papua New Guinea (between 200-400 publications). The numbers of co-publications with a New Zealand partner are more moderate (between 100-200 with Fiji, New Caledonia and Australia). Australia also publishes a similar number with the Solomon Islands, as does India with Fiji and New Caledonia with French Polynesia (these last two which may be explained by strong cultural ties).

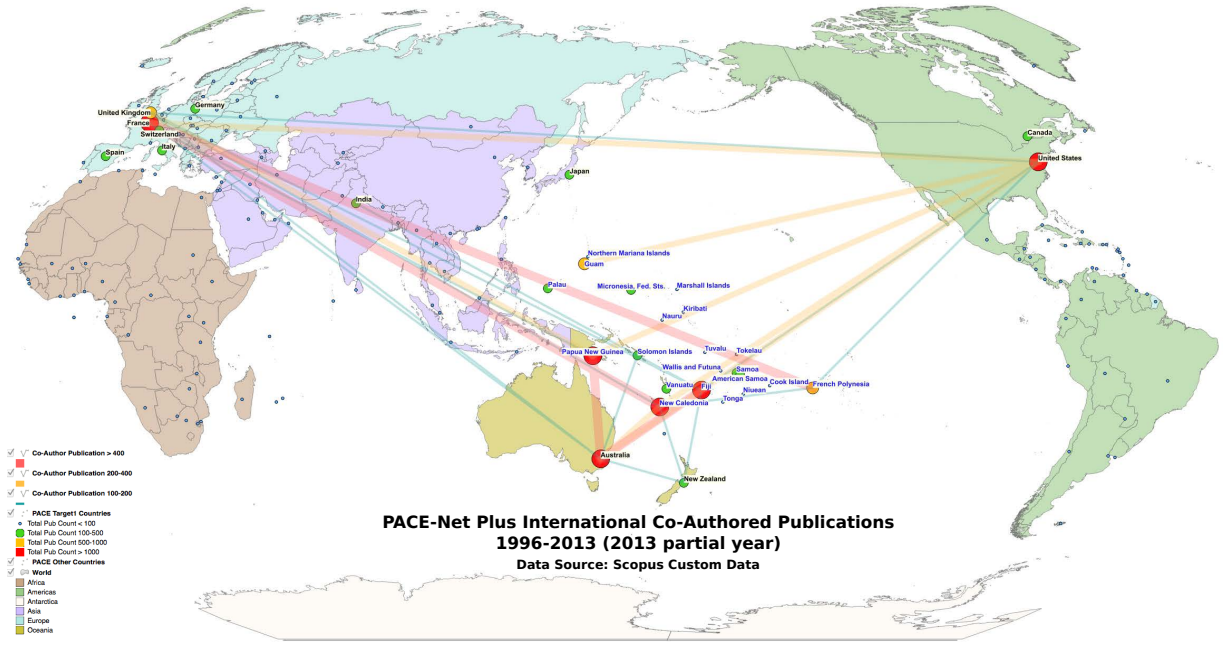

Figure 1a. Volumes of publications with at least one Pacific author (by country) and collaboration patterns of co-authored publications

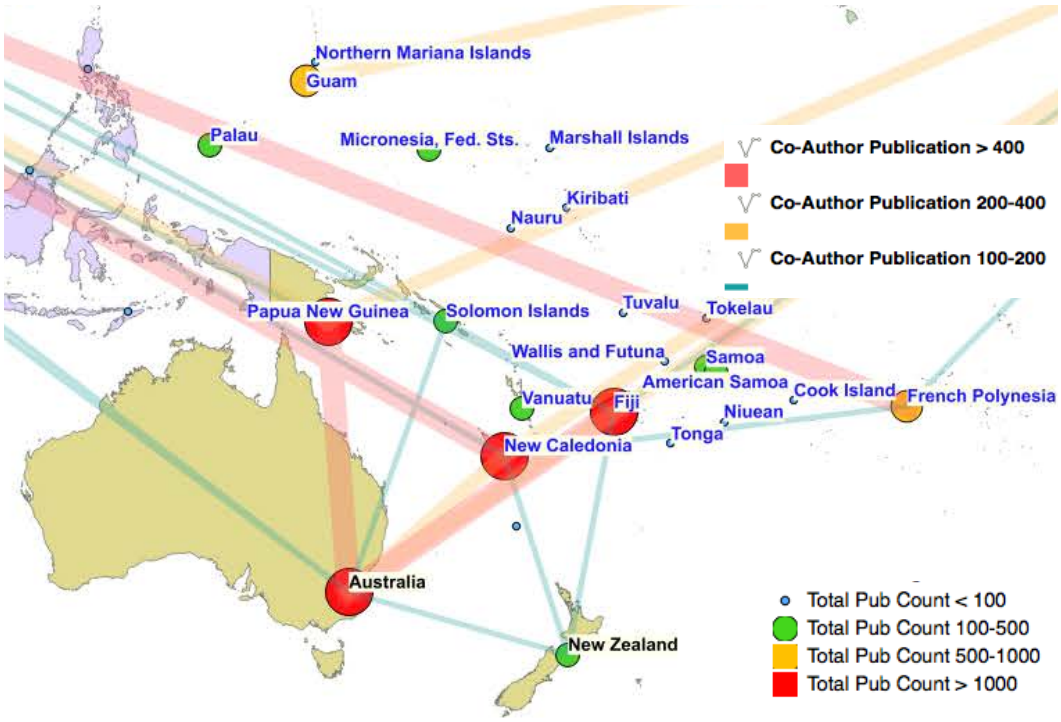

Figure 1b. Zoom on the Pacific: volumes of publications with at least one Pacific author (by country) and collaboration patterns of co-authored publications

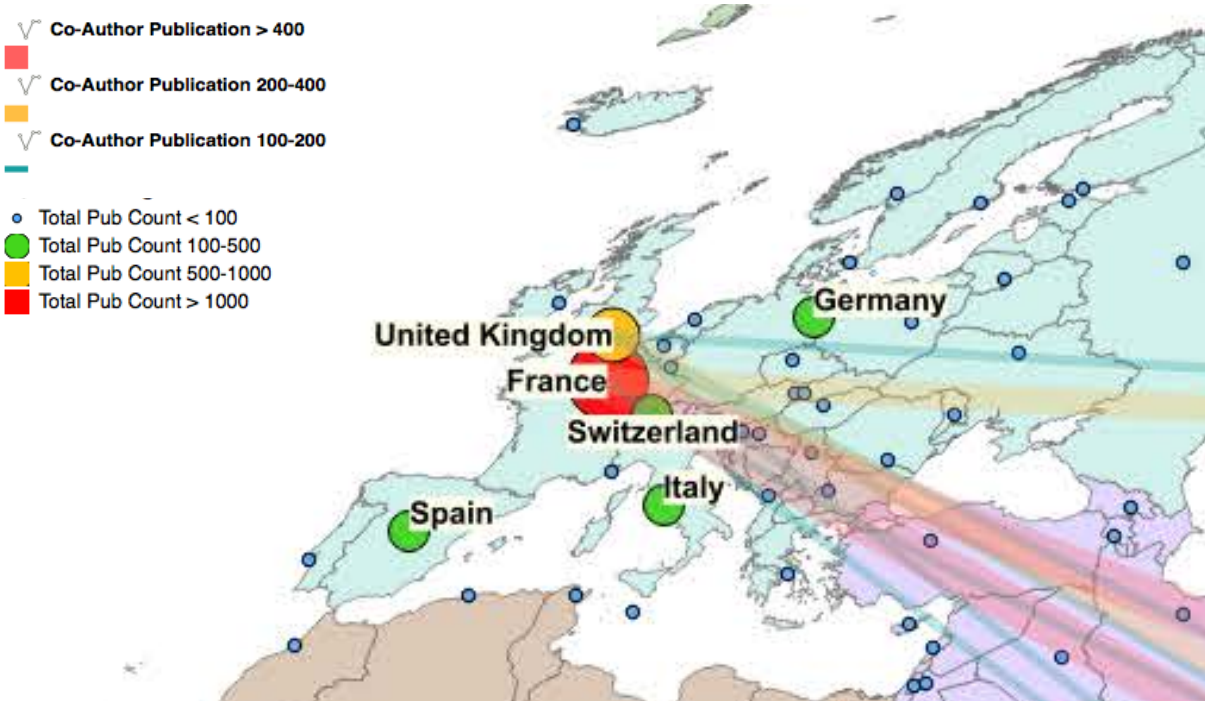

Figure 1c. Zoom on Europe: volumes of publications with at least one Pacific author (by country) and collaboration patterns of co-authored publications

Table 1. Pacific publication volumes

Country	Publication count
Papua New Guinea	1752
Australia	1727
New Caledonia	1600
Fiji	1554
USA	1542
France	1387
French Polynesia	959
Guam	612
United Kingdom	566
New Zealand	425

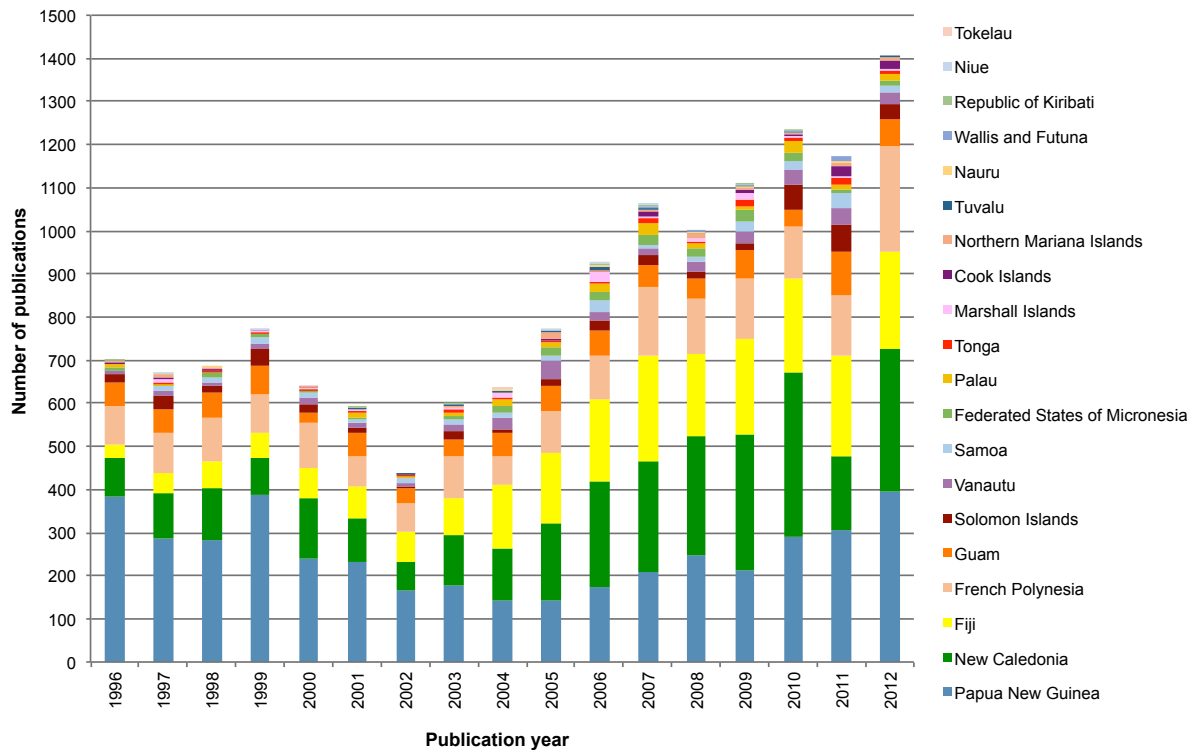

Figure 2. Pacific Island Country and Territory annual publication volumes

Table 2. Pacific publication collaboration volumes

Country 1	Country 2	Publication volume
France	New Caledonia	780
Australia	Papua New Guinea	692
France	French Polynesia	522
Australia	Fiji	457
Papua New Guinea	USA	344
Australia	USA	318
Guam	USA	298
Australia	New Caledonia	258
New Caledonia	USA	257
United Kingdom	Papua New Guinea	221
France	USA	212
French Polynesia	USA	200

PICT publication collaborations at the institutional level are presented in Figure 3. Only publications with 5 or more citations are presented to have an understanding of quality.

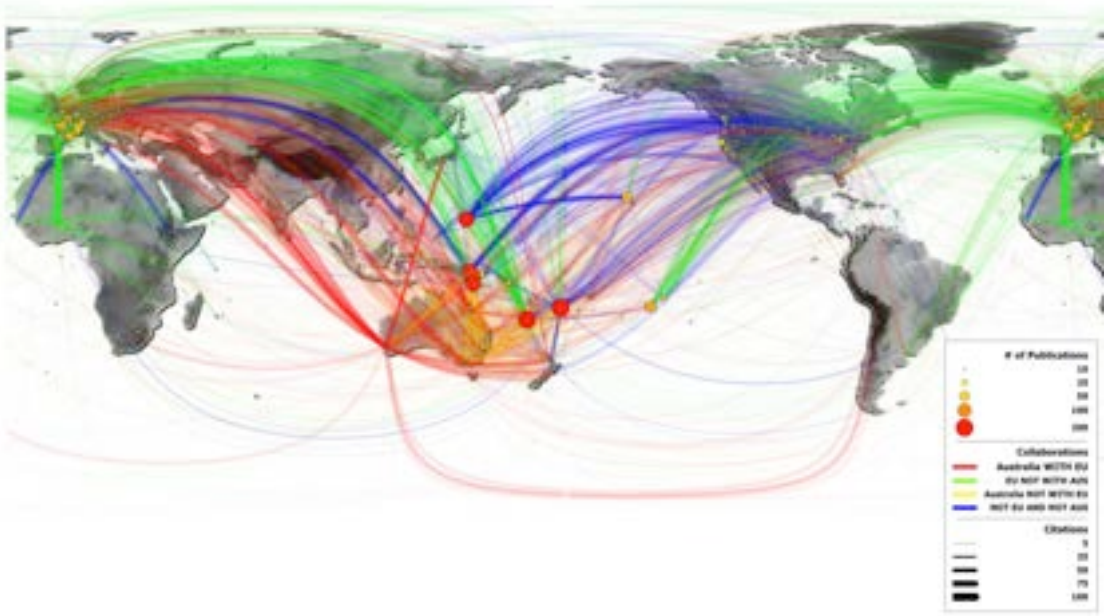

Figure 3. Pacific publication collaborations per institution with publication and citation volumes

From Figure 3, it is possible to see that many of the PICT publications emanate from a few key institutions in New Caledonia, Fiji, Papua New Guinea and Guam, yet their collaborators in Australia, France, the USA and New Zealand stem from many different institutions (or parts of institutions with different physical addresses). In other words, there are not just a few key external partners to PICTs but many.

In Figure 3, the visualisation of PICT publication collaborations has been divided into categories by whether there is an EU and/or Australian co-author due to both French and Australians appearing commonly as co-authors on PICT publications (see Table 2 and 1). Quality measured in terms of citations appears to follow volume along the pattern shown in Table 2. For example there are large numbers of quality publications co-authored between New Caledonian and French authors. What is perhaps more interesting is that PICT publications that are co-authored with both an Australian and European partner (and in some cases a US author as well) are particularly highly cited (the thicker red lines). The impact of multi-lateral collaboration for Australian authors had already been established by the bibliometric analyses carried out in the FEAST bilateral project (e.g. Matthews et al., 2009). These analyses presented in this report thus confirm the potential impact importance of multi-lateral collaborative research, and show that this pattern also holds true for PICT authored papers. It also provides the evidence that the tri-lateral approach of the PACE-Net Plus project to enhance scientific collaboration between PICTS, Australia/New Zealand and Europe could indeed lead to higher quality scientific research, measured in the form of citations of co-authored papers.

The following section with further analyse this potential.

4.2 Potential for collaboration with the EU (and Australia/New Zealand) around societal challenges linked to Pacific current capacity and interest

As shown in the previous section, the total number of research institutions in the Pacific that are producing high quality research (measured here only by citations, which we recognise is not the only possible indicator of quality) are relatively few. From the use of the topic model with the PICT authored papers, it was seen that Pacific research that fits this category is concentrated in a number of key areas. Those with the highest volumes can loosely be classified as:

- Coral reef ecology
- Conservation management
- Diseases (including HIV) and public health
- Education and cultural knowledge
- Tropical forestry, agriculture and invasive species
- Community development and capacity building
- Populations and genetic diversity
- Fisheries and resource management
- Climate and oceanography
- Economic development, governance and public policy
- Energy (renewable)

As explained in Section 3.2, the PICT author paper set was then expanded to include more papers from the global research community dealing specifically with Pacific-focussed topics (i.e. those mentioning PICTs). It was from this set that the topic model was developed that was used for extracting European and Australian/New Zealand publications on similar topics matched to each of the three societal challenge areas of interest to the PACE-Net Plus project (see Section 1). The following sets of Figures present the results of this method looking first at total volumes of relevant publications and collaborations globally, then by also highlighting volumes of existing collaborations in the topic areas between PACE-Net Plus target Pacific and European countries:

- Figures 4a-d on health, demographic change and wellbeing;
- Figures 5a-d on food security, sustainable agriculture, marine and maritime research and the bio-economy; and
- Figures 6a-d on climate action, the environment, resource efficiency, and raw materials.

Discussion on these results will follow the Figures.

Figure 4a. Total existing collaboration potential with PICTs in the field of health, demographic change and wellbeing

Figure 4b. Total existing collaboration potential with PICTs in the field of health, demographic change and wellbeing with PACE-Net Plus target country institution collaborations highlighted

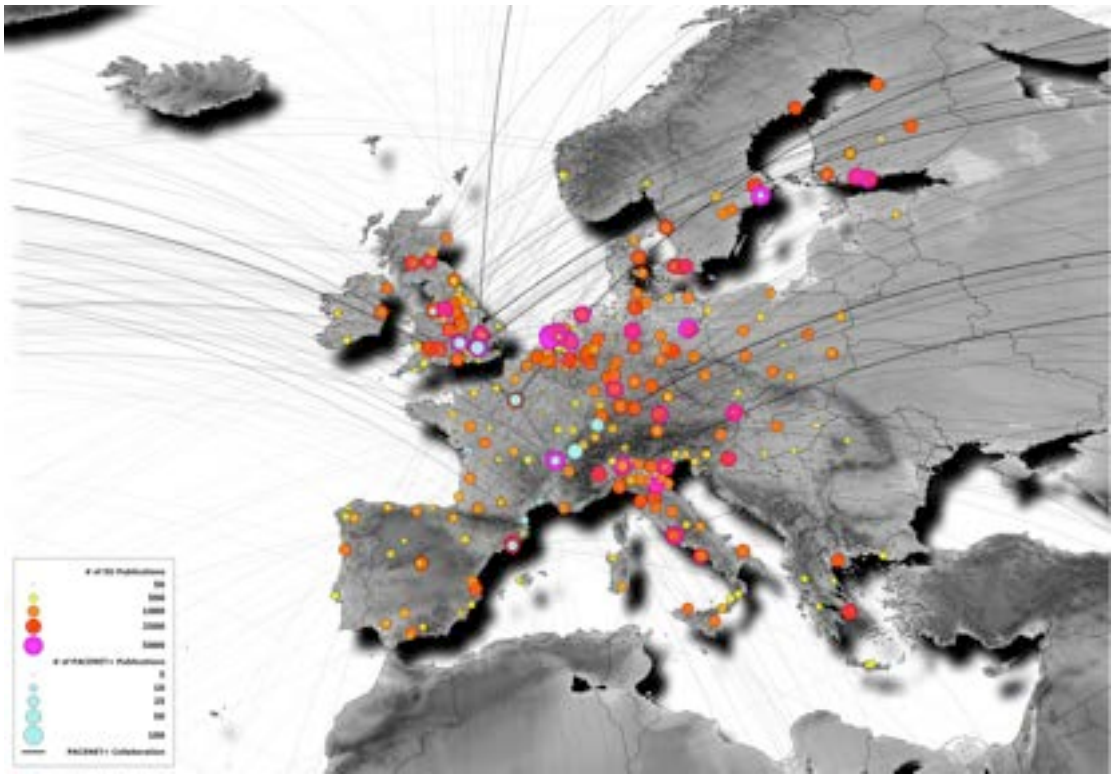

Figure 4c. Zoom on Europe from Figure 4b.

Figure 4d. Zoom on the Pacific from Figure 4b.

Figure 5a. Total existing collaboration potential with PICTs in the field of food security, sustainable agriculture, marine and maritime research and the bio-economy

Figure 5b. Total existing collaboration potential with PICTs in the field of food security, sustainable agriculture, marine and maritime research and the bio-economy with PACE-Net Plus target country institution collaborations highlighted

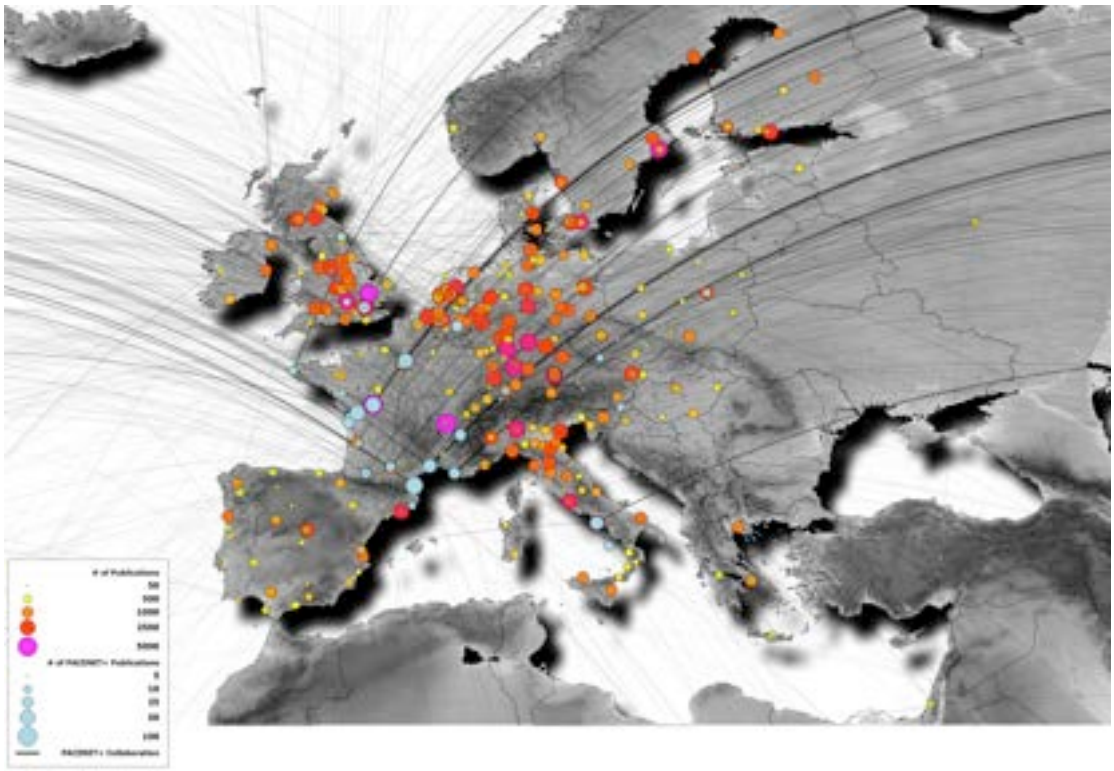

Figure 5c. Zoom on Europe from Figure 5b.

Figure 5d. Zoom on the Pacific from Figure 5b.

Figure 6a. Total existing collaboration potential with PICTs in the field of climate action, the environment, resource efficiency, and raw materials

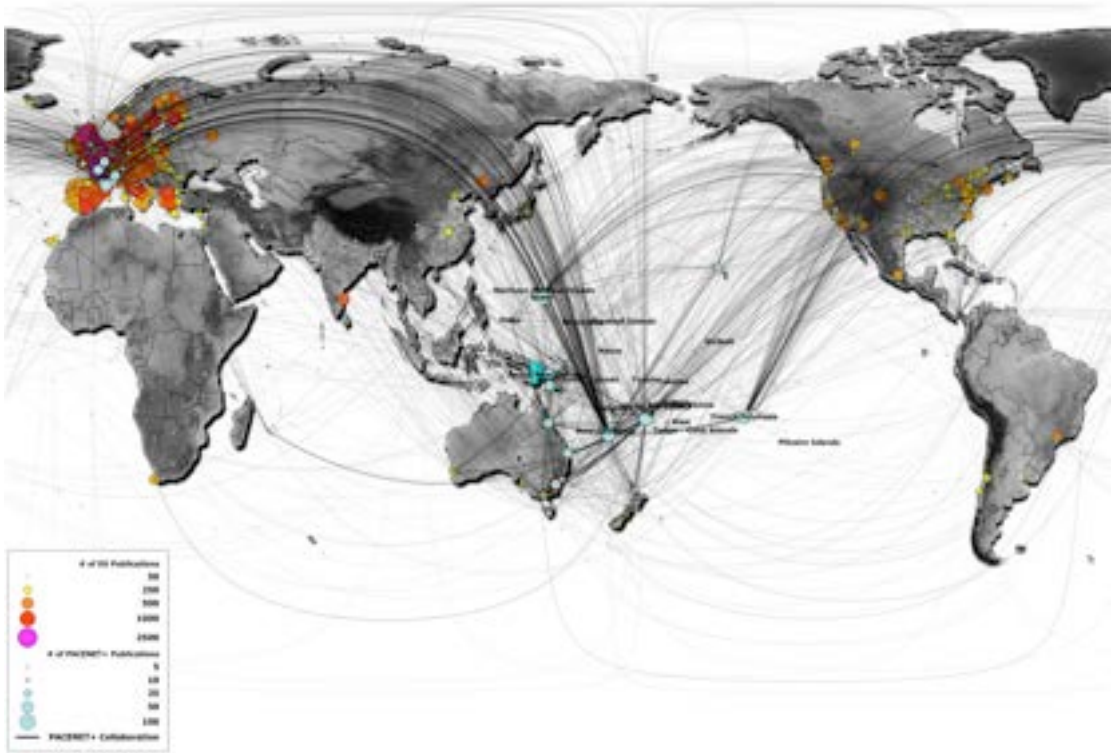

Figure 6b. Total existing collaboration potential with PICTs in the field of climate action, the environment, resource efficiency, and raw materials with PACE-Net Plus target country institution collaborations highlighted

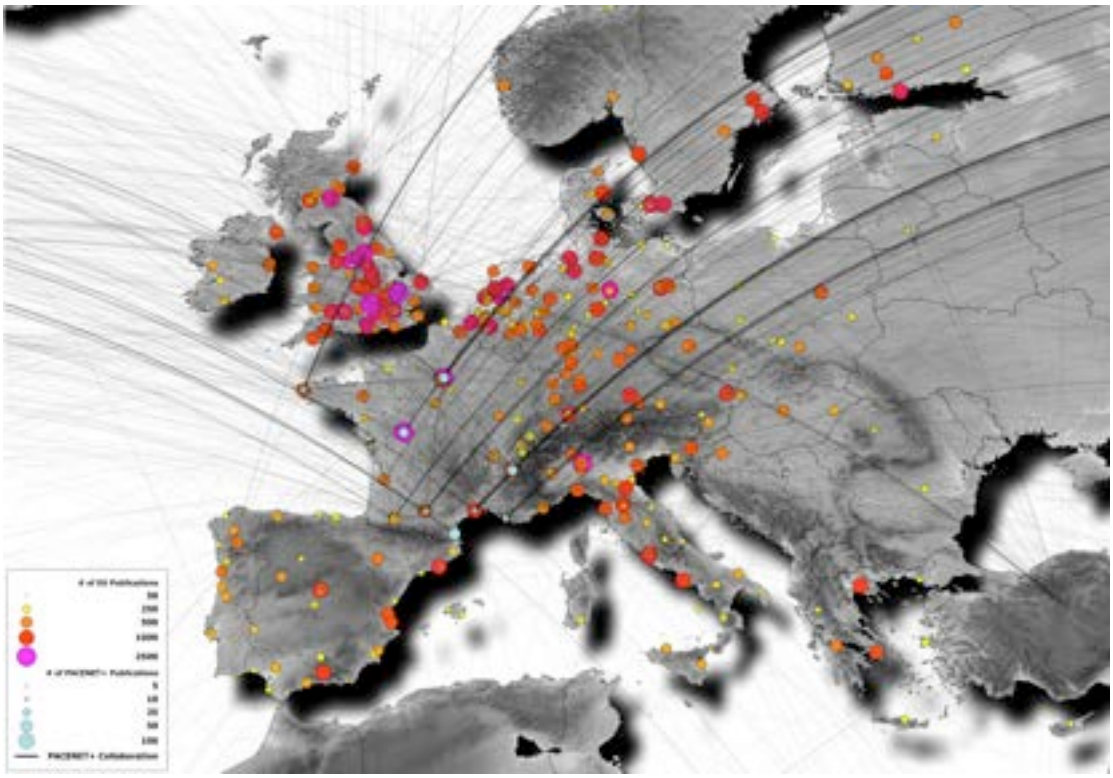

Figure 6c. Zoom on Europe from Figure 6b.

Figure 6d. Zoom on the Pacific from Figure 6b.

From Figures 4a to 6d, it can be observed that there are large amounts of research being produced in each of the three societal challenge areas by Europeans and to a lesser, but still significant extent, Australia and New Zealand. There is also additional collaboration in these areas between the EU and Australia and New Zealand that is not captured as part of the PICT co-authored papers (see for example the difference between Figures 6a and 6b).

Of the total publications extracted over the three themes, approximately 45% were found in the Societal Challenge 1 (652737 publications), 35% were found in the Societal Challenge 2 (492114 publications) and 20% were found in the Societal Challenge 5 (274901 publications), which can be seen in the complexity and volumes of publications and collaborations. The breakdown of these publications per sub-theme area can be seen in Figure 7.

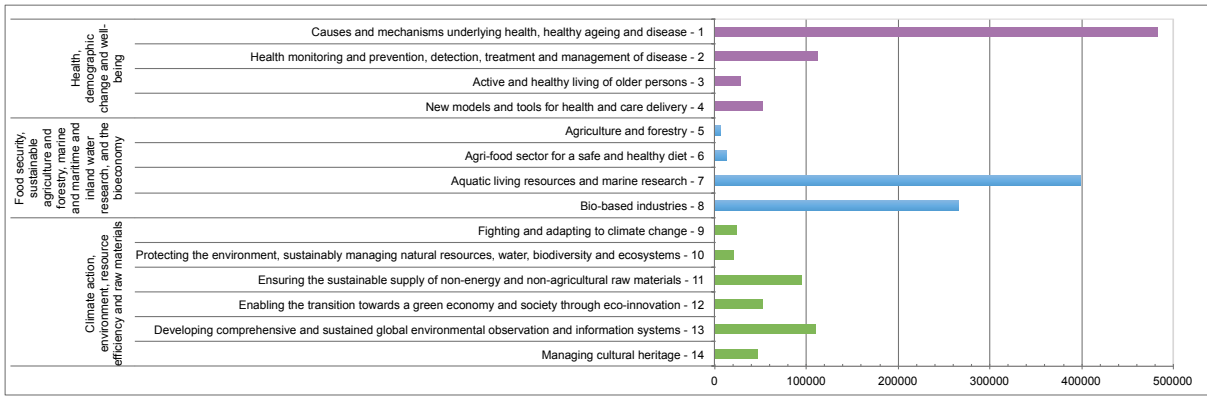

Figure 7. Numbers of extracted EU and Pacific (including Australia/New Zealand) publications per societal challenge sub-theme area

As shown in Figure 7, three of the subcategories account for much higher levels of extracted publications than the other eleven: causes and mechanisms underlying health, healthy aging and disease; aquatic living resources and marine research; and bio-based industries. The four lowest areas of publications were extracted in the areas of: agriculture and forestry; agri-food sector for a safe and healthy diet; fighting and adapting to climate change; and protecting the environment, sustainably managing natural resources, water, biodiversity and ecosystems. From the initial topic model of PICT publications, we can see that many of these last subcategories are of particular scientific interest (and societal need) in the Pacific. Specifically approximately a third of PICT publications could be allocated to Societal Challenges 2 and 5 (2423 and 2457 publications respectively) and 20% to Societal Challenge 1 (1557 publications). The rest did not fit into these target areas.

To some extent there is thus a mismatch between European and Pacific interests, but also potentially some good opportunities for PICT scholars to work with the fewer European (and Australian/New Zealand) institutions with an interest in these areas as equal partners. This will be further investigated in the discussion, Section 5.

The next set of figures 8-10 outline the top 50 disciplines or subject areas (using the Scopus “All Science Journal Classification (ASJC)” codes) with corresponding numbers of extracted publications for each in the three societal challenge areas.

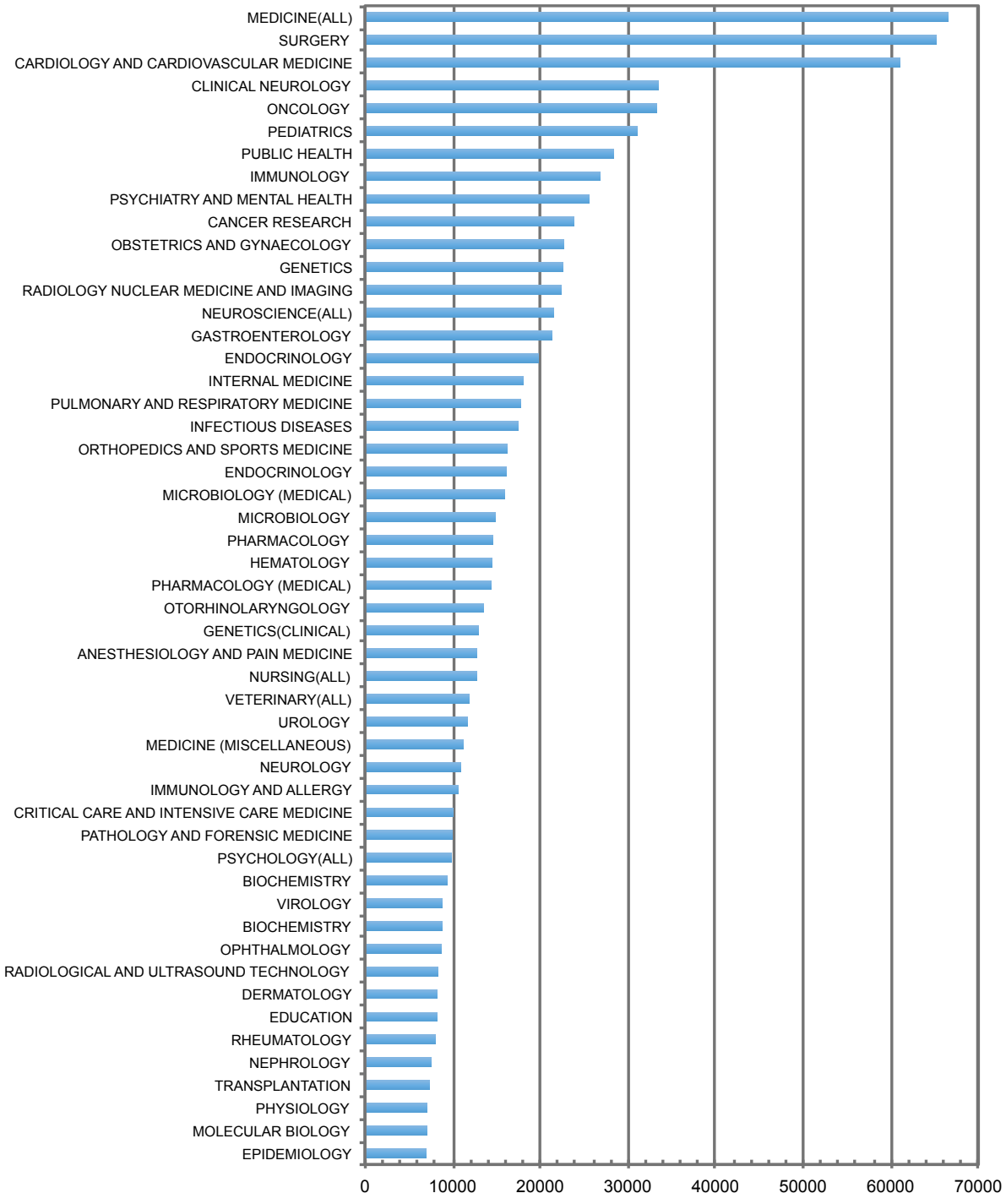

Figure 8. Volume of extracted publications across the top 50 disciplines (ASJC codes) in field of health, demographic change and wellbeing

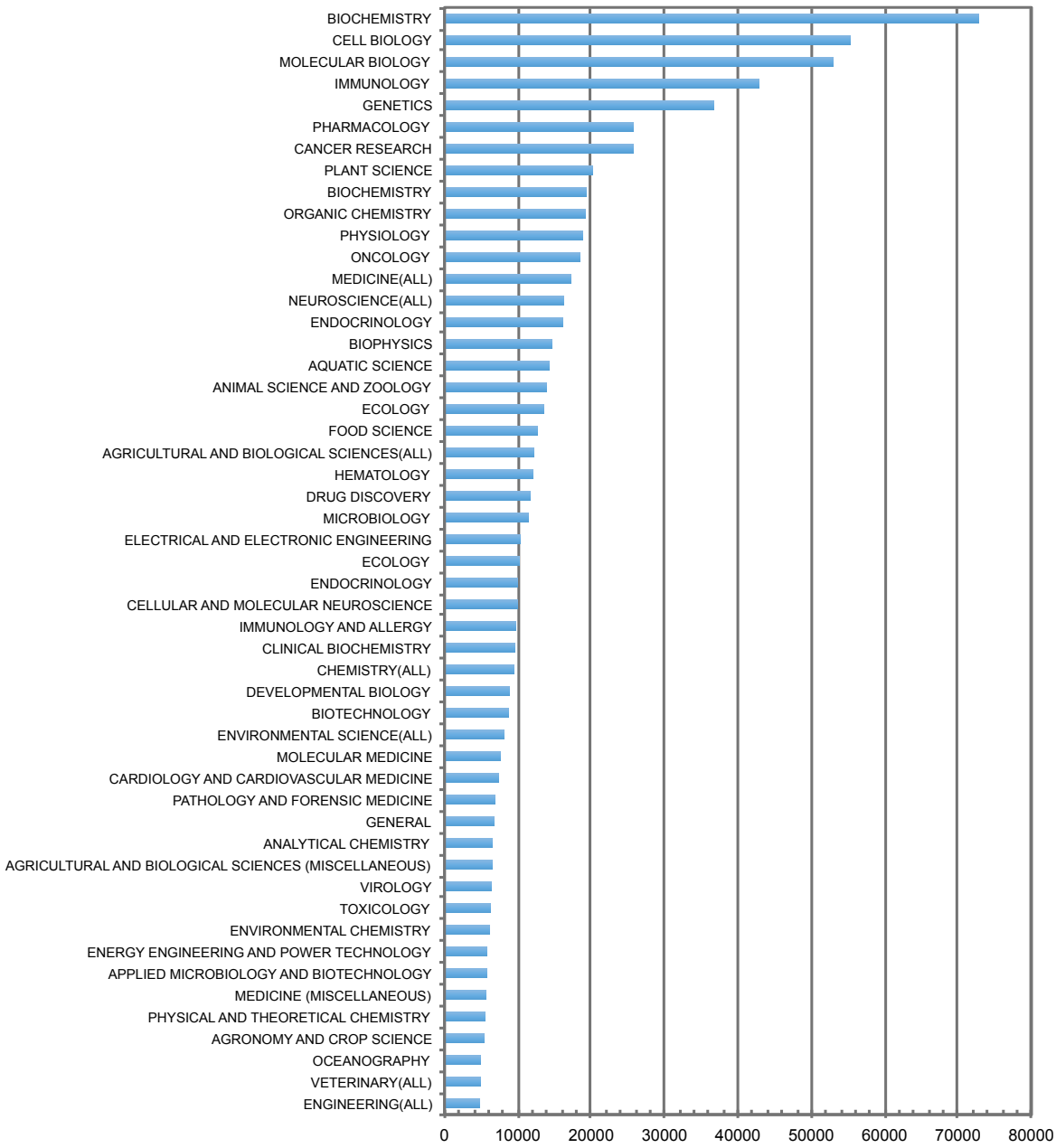

Figure 9. Volume of extracted publications across the top 50 disciplines (ASJC codes) in field of food security, sustainable agriculture, marine and maritime research and the bio-economy

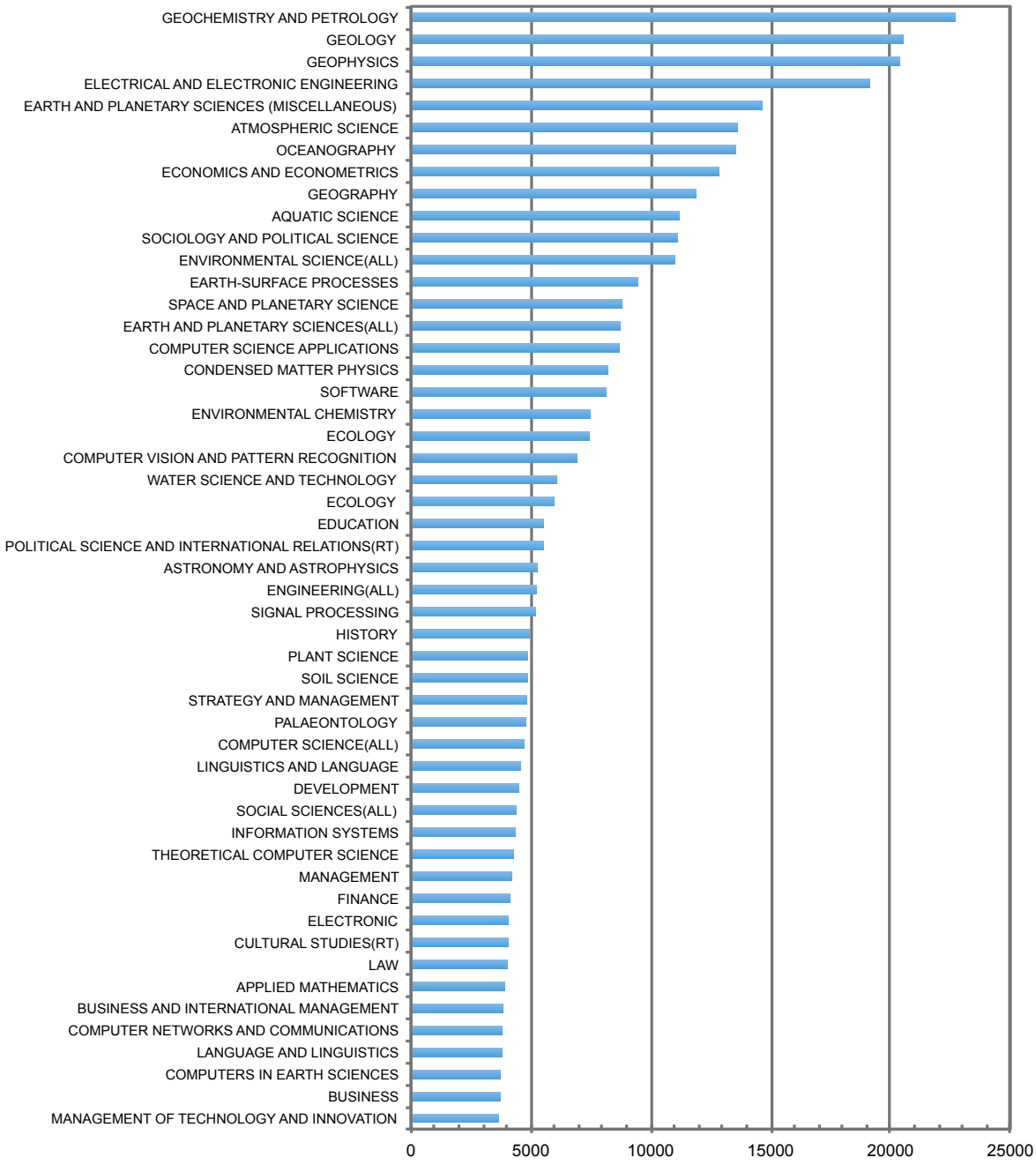

Figure 10. Volume of extracted publications across the top 50 disciplines (ASJC codes) in field of climate action, the environment, resource efficiency, and raw materials

From Figures 8-10 it can be seen that different disciplines are allocated across the themes with a strong focus on: medical sciences in Challenge area 1; biochemistry and biology in Challenge area 2; and geochemistry/geophysics and other earth-related sciences in Challenge area 5. A brief look at the actual articles extracted reveals that the majority focus

on fundamental/basic experimental science questions and that relatively fewer are concerned with more applied research. For example, this can be seen most evidently in the number of fundamental versus applied categories and their respective volumes in Figure 9. Societal Challenge area 5 has a larger number of applied categories including engineering and economics, as could perhaps be expected.

Examining the potential for supporting Europe-Pacific collaboration in these challenge areas further, Figures 11-13 present the evolution of the top 20 countries' volumes of publications per annum in each area. We note that as per Section 3.2, the volumes of publications outside the PACE-Net Plus target set (e.g. USA, Japan, China) only represent a volume of co-publications with at least one author in the target set.

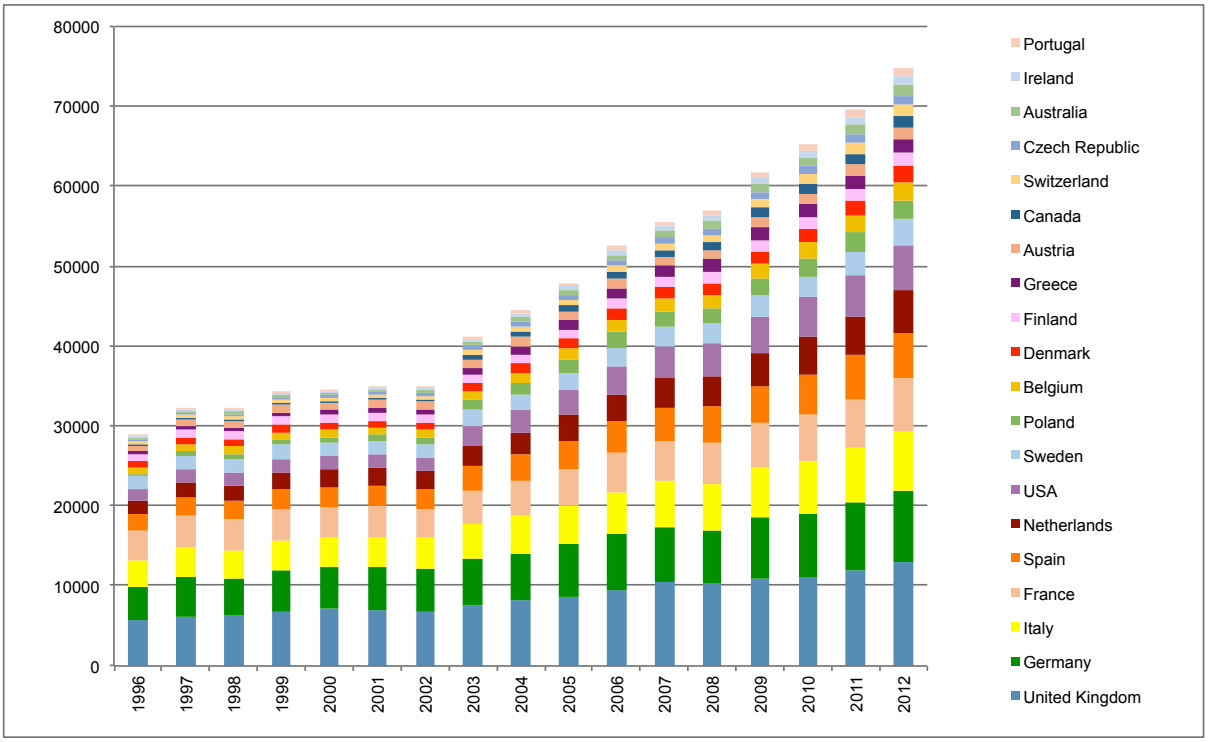

Figure 11. Annual volumes of extracted publications per country in the field of health, demographic change and wellbeing

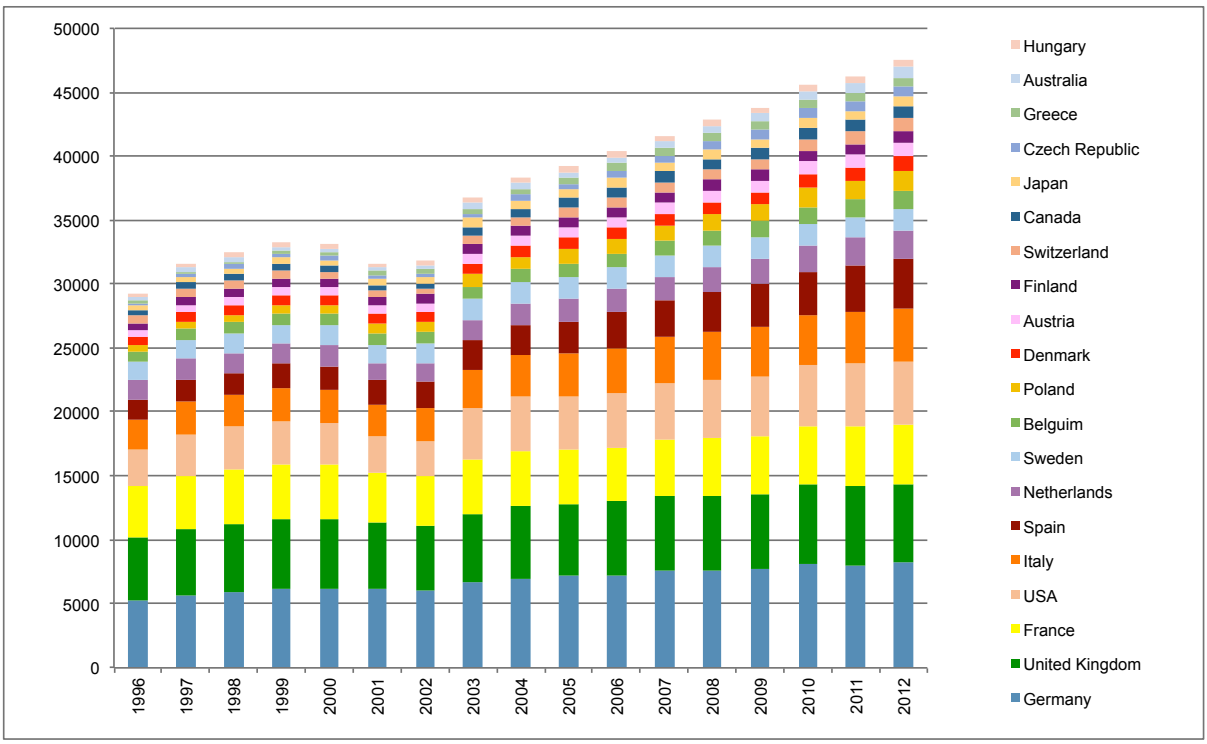

Figure 12. Annual volumes of extracted publications per country in field of food security, sustainable agriculture, marine and maritime research and the bio-economy

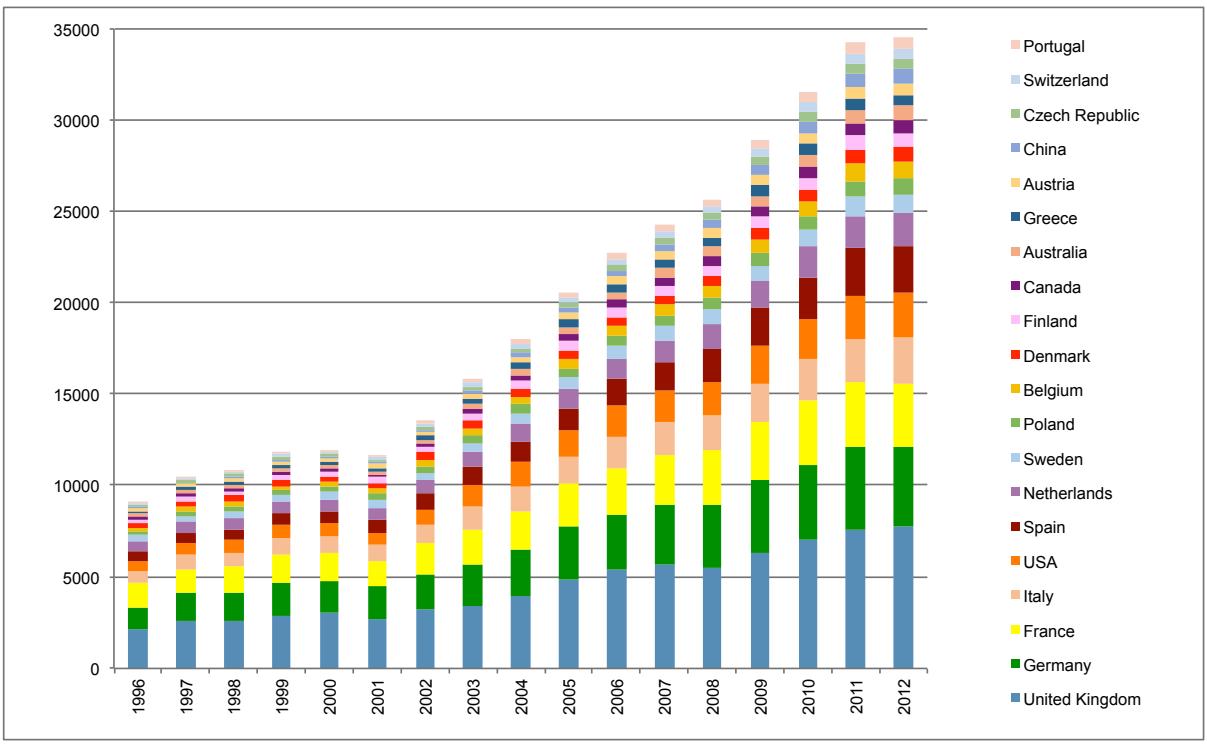

Figure 13. Annual volumes of extracted publications per country in the field of climate action, the environment, resource efficiency, and raw materials

Across the three challenge areas, the top publishers are consistently the United Kingdom and Germany, followed by France and Italy, then Spain, the Netherlands and Poland (when not considering the USA co-publications). Australia makes it into the top 20 publishers in each of the areas, and interestingly, so does the USA and Canada just with their co-publications. Japan also appears in Challenge area 2 and China in Challenge area 5.

5 Discussion, conclusions and perspectives

In volumes of publications alone, in the areas of interest of Pacific scholars linked to the EU societal challenges treated in the PACE-Net Plus project, there is clearly an issue of scale mismatch between those produced by European countries and those in the Pacific region (approximately 1.4 million compared to 6437 publications). As mentioned in Section 4.2, there is also to some extent a partial mismatch between European and Pacific interests in volumetric terms.

However, the results also show that, as the EU and Australian/New Zealand publications are extracted based on topics of Pacific expertise as demonstrated by papers published in outlets referenced by Scopus, that there is in fact great potential for growing scientific collaboration.

5.1 Developing collaboration potential

Of the EU countries, France has by far the largest co-publication outputs with PICTs across all three societal challenge areas, focussed on the French-speaking New Caledonia and French Polynesia. The United Kingdom follows, with co-publications principally with Papua New Guinea and Fiji focussed on Challenge area 1. Other countries such as Italy have a few collaborations with PICTs, in Challenge area 2. Yet, compared to its large output in the three challenge areas, Germany appears to have very few co-publishing relationships with PICTs of significant volumes. Reasons for this could be multiple including a lack of exposure to the Pacific and PICT researchers, differences in academic focus in these topic areas, and cultural differences and costs that challenge productive co-publishing. Similar reasons may exist for other EU countries.

Australia (followed by the USA) is the other target country that has particularly strong collaborations with PICTs including Papua New Guinea, Fiji, New Caledonia and others. It also has strong research and co-publishing relationships with the UK, Germany, France and

Italy, sometimes in multi-lateral contexts as demonstrated in Figure 3 or just bi-laterally as shown in Figures 4a, 5a and 6a. In terms of developing further EU-Pacific collaboration, there may be potential to develop increased multi-lateral relationships with Australia (and New Zealand) who already have strong relationships and some cultural ties with PICTs, allowing them to act as "brokers" between cultures and geographies. This may have the additional payoff of creating higher quality and more cited research, since multi-country authored papers are consistently seen to be more highly cited than single or bi-country publications, as noted already in Section 4.1.

As discussed in Adams et al. (2010), using Thompson Reuters Web of Science data between 2004-2008 (rather than the Scopus data that has been used here) both Australia and New Zealand are also world leaders in many of the disciplinary areas of interest to PICTs where there could be potential for collaboration with Europe. For example, Australia and New Zealand together, despite their small populations, account for just over 10% of the world's scientific output in "marine and freshwater biology", and "fisheries" and between 8% and 10% in "agriculture, multidisciplinary", "oceanography", "ecology", "biodiversity conservation", "oceanography", "mineralogy" and "evolutionary biology". All of these are Pacific-relevant and hence Europeans may be able to develop fruitful partnerships in these areas with Australian and New Zealand researchers, as well as with PICT researchers.

The other approach for European researchers with an interest in developing PICT collaborations, where they do not already exist, is to work with colleagues in France or the UK (or others who already have working research collaborations) to again develop multi-lateral research.

5.1 Study limitations and perspectives for future research and analyses

This report provides mainly country-level analyses of publications and some institutional-level visualisations across the three societal challenge areas targeted by the PACE-Net Plus project. This level of analysis to some extent covers the results at the lower subtheme level (e.g. as provided in Figure 7) where, for example, Italy and the Netherlands produce the largest number of publications in the "causes and mechanisms underlying health, healthy aging and disease" subtheme and Austria possesses one institution in the top 10 publishers. Similar analyses at an institutional level could be looked at for all the other sub-themes for both those already involved or not involved in PICT collaborations. These could then be

used by institutions and partners to learn more about current research in specific thematic areas of interest to them and to target potential partners for future collaboration. Likewise, author-level analyses in specific discipline areas may be of interest for establishing effective and productive research collaborations. Examples of such example analyses are available in Matthews and Cheng (2014).

The other major limitation of this work is linked to the particular methodology chosen based on the idea of topic modelling. All publications extracted in this study are based on past PICT or Pacific-related research of 60 topic model sets, and allocated to the sub-themes, as explained in Section 3.2. This means that some of the publications may be overly narrow with relatively few publications found (see for example forestry and agriculture in Figure 7) due to the specificity of such PICT research published in international journals or conferences referenced by Scopus. One suggested way of overcoming this issue in order to look for all EU and Australian/New Zealand research relevant to the challenges according to the keywords as shown in Appendix 2. Such an approach has been taken in the Australian Chief Scientist's work on Strategic Research Priorities and could be repeated for EU-Pacific collaboration identification and potential building purposes.

Finally, these EU-Pacific analyses only focus on three Horizon2020 societal challenges. The analyses could thus be expanded to others and potentially to other geographical regions around the world. Such analyses could be the focus of other regional INCO-Net projects or future EU network building projects.

6 References

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