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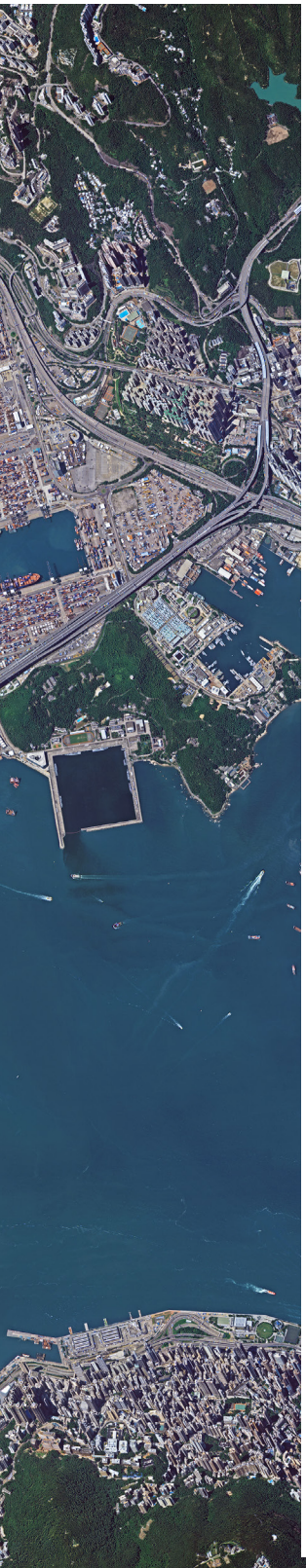
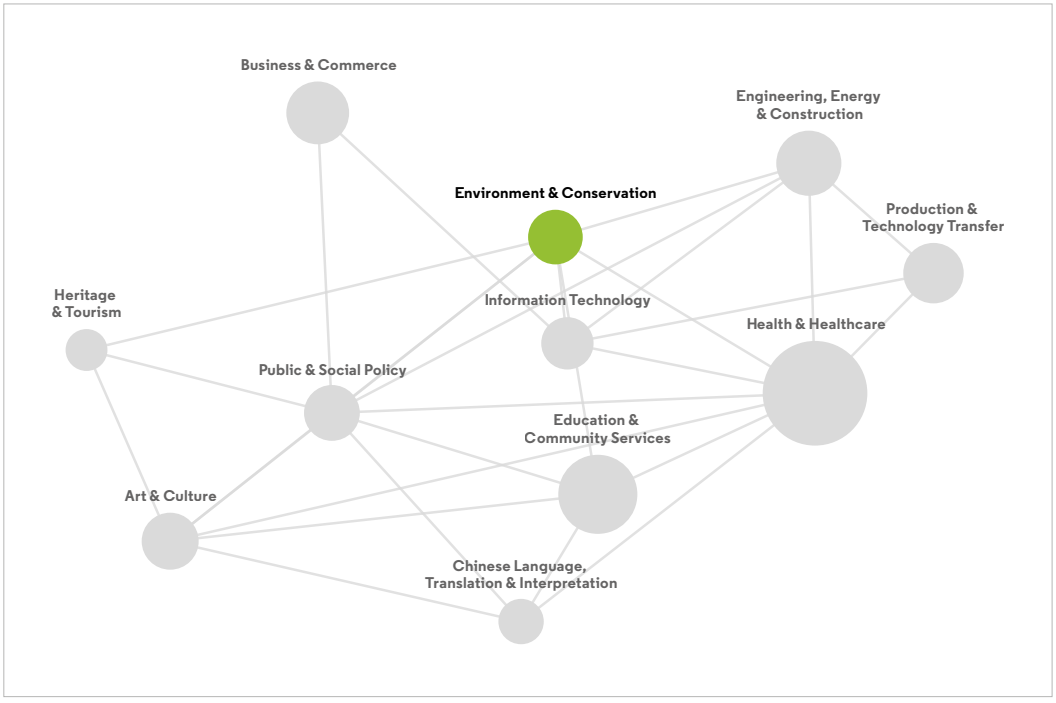
UGC RAE 2020 HK 研究評審工作 Research Assessment Exercise 2020 HONG KONG 大學教育資助委員會 UNIVERSITY GRANTS COMMITTEE



The societal impact of research undertaken by Hong Kong universities:

Environment & Conservation

A synthesis of the RAE 2020 impact case studies



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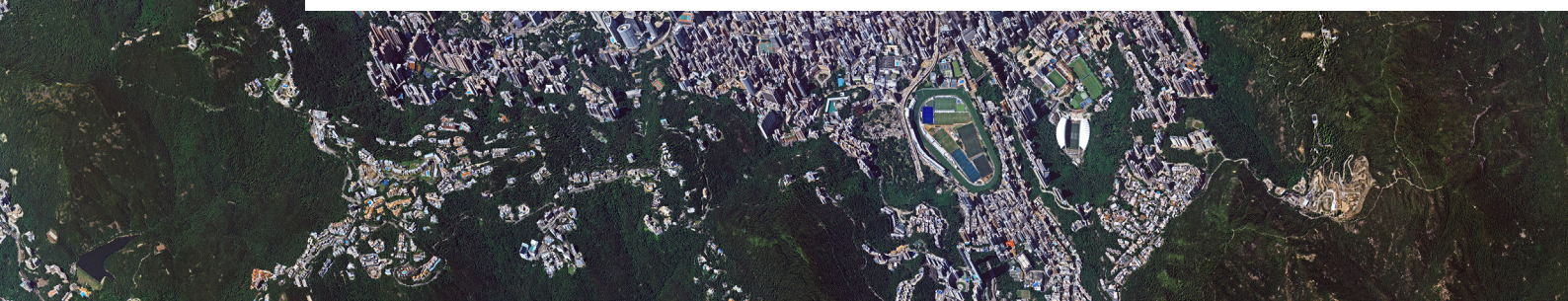


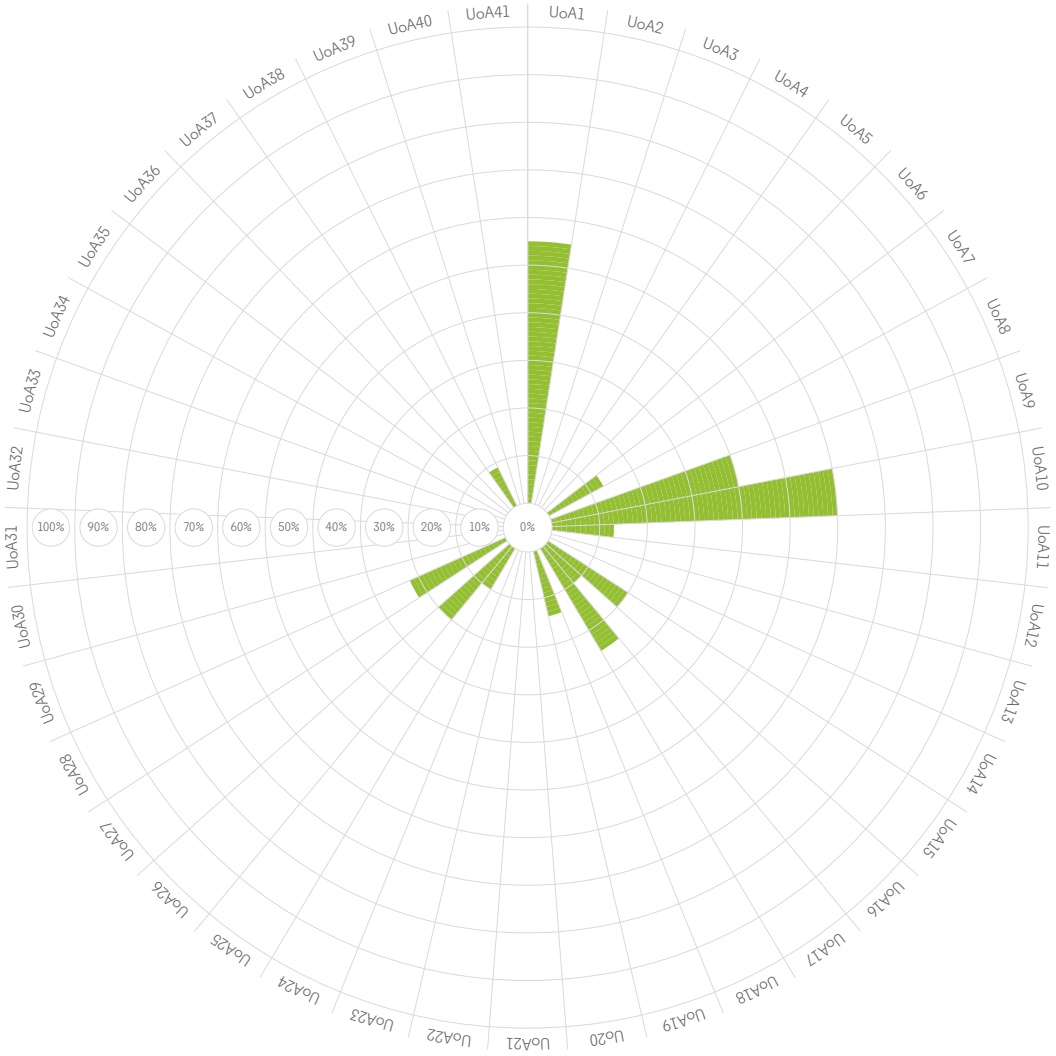
This report is part of a series of outputs that examines the impact of research arising from eight universities based in Hong Kong and funded by the University Grants Committee (UGC). The report focuses on the Impact Case Studies (ICS) produced by the UGC-funded universities as part of their response to a Research Assessment Exercise (RAE) in 2020. The overarching report - *The impact of research undertaken by universities in Hong Kong: A synthesis of the RAE 2020 impact case studies* – is accompanied by 11 thematic reports that examine the nature of research impact in different areas, ranging from Arts & Culture to Health & Healthcare. The 342 impact case studies that are analysed through this body of work are also available on a searchable database that is posted on the UGC's website.

The Environment & Conservation cluster contains 25 impact case studies (ICS) from three primary topics identified in the topic modelling.[1] The Environment & Conservation cluster covered 7% (i.e. 25/342) of ICS submitted to RAE 2020.

The impact wheel in Figure 1 illustrates how the Environment & Conservation cluster is distributed across the 41 Units of Assessment (UoAs) used for RAE 2020. For example, for UoA 1 (biological sciences), six of the eleven ICS (= 55%) submitted to this UoA were allocated to the cluster.

Overall, the impact wheel shows that the 25 ICS came from 13 UoAs: UoA 1 (biological sciences); UoA 7 (physics & astronomy); UoA 9 (chemistry); UoA 10 (earth sciences); UoA 11 (mathematics and statistics); UoA 15 (chemical engineering, biomedical engineering, other technologies and marine engineering); UoA 16 (civil engineering and building technology); UoA 17 (architecture); UoA 19 (law); UoA 25 (political science); UoA 26 (geography); UoA 28 (social work and social policy); and, UoA 38 (visual arts, design, creative media, other creative arts and creative writing).

Figure 1: Impact wheel for the Environment & Conservation cluster (n=25)



[1] See methodological annex for details.

The impact of Hong Kong universities' research: **Environment & Conservation**

Table A shows the most salient features of the case studies in terms of beneficiaries, location, type of impact and time lag. It gives the percentage of case studies in this cluster that were tagged with sub-codes under these code headings, as well as the percentage of case studies tagged with those sub-codes in the entire sample of 342.

The 25 case studies in this cluster benefited three key sectors under the classification of the Hong Kong Standard Industrial Classification: 40% benefited Water supply, sewerage, waste management, and remediation activities, 28% Human health and social work activities and 20% Agriculture, forestry and fishing. The key socioeconomic group was citizens/communities, with 12% of case studies relating to this group. The primary decision taker groups that were involved were government departments/agencies (28%), global political decision makers (16%) and the private sector (16%). Beyond Hong Kong (68%), the Greater Bay Area (8%) and Mainland China (16%), these case studies primarily had an impact in the United States (20%) and Japan (8%). The most salient type of impact was informing procedure, practice or protocol (72% of case studies in this cluster), followed by advancing policy debate (36%), informing government policy (24%) and informing guidelines or strategy (20%). Interestingly, on average, the underpinning research in this cluster was started in 2003, compared to 2006 for the whole sample. This suggests a relatively long lag between the start of the research and the relevant impact. The median publication date for this cluster was 2013, slightly earlier than for the whole sample (2015).

On reading the ICS in the Environment & Conservation cluster it was evident that the majority could be grouped into four subthemes, which in and of themselves were also quite diverse: pollution, environment and health, sustainable agricultural practices, and community building.

Table A: Some salient features of research impact identified in the Environment & Conservation cluster (n=25)

Beneficiaries of impact (top mentions)	**% of cluster impact case studies**	**% of all impact case studies**
Hong Kong Standard Industrial Classification		
Water supply, sewerage, waste management, and remediation activities	40%	4%
Human health and social work activities	28%	34%
Agriculture, forestry and fishing	20%	2%
Sociodemographic group		
Citizens/communities	12%	17%
Decision taker group		
Government departments/agencies	28%	31%
Political decisions makers (Global)	16%	6%
Private sector	16%	30%
Location of impact	**% of cluster impact case studies**	**% of all impact case studies**
Hong Kong	68%	75%
Greater Bay Area (excluding Hong Kong)	8%	3%
Mainland China (excluding Hong Kong and GBA)	16%	12%
United States	20%	32%
Japan	8%	11%
Type of impact (top mentions)	**% of cluster impact case studies**	**% of all impact case studies**
Inform procedure, practice or protocol	72%	52%
Advance policy debate	36%	13%
Inform government policy	24%	23%
Inform guidelines or strategy	20%	27%
Elapsed time	**Cluster**	**All**
Median year of research commencement	2003	2006
Median year of publication date	2013	2015

Pollution

As in many parts of the world, industrialization and development in Hong Kong and the wider Pearl River Delta have resulted in widespread marine pollution, prompting public concern and a policy need to monitor and clean up the marine environment. Basic and applied research from The Hong Kong University of Science and Technology's Coastal Marine Laboratory has contributed to the understanding of environmental toxicology for water quality management and seafood safety in China's coastal areas and beyond. Specifically, the research team quantified how heavy metals transfer along the food chain in the marine ecosystem and show how this pollutant has an impact on public health. Based on this they have developed an approach to estimate metal concentration within marine organisms which is recommended in a number of policy guidelines internationally, notably the US Environmental Protection Agency. This expertise has been used locally with the team advising Hong Kong's Drainage Services Department and the Secretary for Food and Health on monitoring and managing marine pollution within the region.

Another example of how research has helped manage pollution was an ICS submitted by The University of Hong Kong's Department of Physics, this time focused on light pollution. Poorly designed outdoor lighting not only wastes energy, money, and valuable earth resources, but also has negative impacts on ecological systems and possibly on health. With a grant from the Environmental Protection Department, the researchers initiated the first ever survey of light pollution in Hong Kong in 2007. Using a citizen-science approach, 2,000 individuals took reading of the night sky and feed these into the team leading to Hong Kong's first ever light pollution map. Partly as a consequence, in 2011 the Hong Kong Government established a Task Force on External Lighting resulting in a charter published in 2016 that, to date, has over 4,000 signatures who have pledged to turn off external lighting during daylight hours. Additionally, the project has captured the public imagination with significant media coverage, websites, competitions and the inclusion of the topic in the school curriculum.

A third ICS described how research on measuring small particle matters in the air had contributed to the measurement and monitoring of air pollution. Over the past 20 years the Air Group at The Hong Kong University of Science and Technology have pioneered a number of analytical approaches to measuring the concentration of particle matters in the air which is a challenging scientific problem given the large range of concentration levels and the need for simple methods for day-to-day use. As a result of a number of innovations, the research team has generated a reference database on the status of air pollution for the Hong Kong Environmental Protection Department. The data showed that Hong Kong faces two air pollution issues, namely local street-level pollution, and regional smog. This insight resulted in a regional collaboration to reduce air pollution in Hong Kong.

Environment and health

Not unrelated to pollution was a new technology developed by researchers at The Chinese University of Hong Kong that has been applied to disinfect water and purify air. Conventional disinfection treatment such as chlorination and ozonation can generate detrimental by-products, while ineffective UV disinfection may lead to the rise of UV-resistant bacterial strain. The researchers knew that theoretically titanium dioxide (TiO2) could be used as an alternative disinfectant but when applied in practice it often lost its antibacterial properties. They overcame this challenge by developing a novel method to fabricate TiO2 into thin films that subsequently was applied to air filtration units and even a self-disinfecting door handle. The research team patented their innovation and licenced it to a local company which has launched a number of new products for air and water treatment systems under the trade name of Nano-Fotocide™ since 2002. Additionally, a license was also granted to a multi-national company, AYKOW, in a non-exclusive deal in 2015. AYKOW has incorporated the technology into a series of antibacterial air filtration systems selling to 3,500 clients through distributors such as Carrefour, Sundan, Boulanger and Leroy Merlin.

Another example of an ICS that described the confluence of environmental contamination and its impact on health was submitted by researchers from the department of Biomedical Sciences at City University of Hong Kong. This ICS documented how a test was developed for endocrine disrupting chemicals (EDC) which, although having harmful effects on growth, reproduction, metabolism, immunity and behaviour, are widely found in various consumer products. The researchers isolated a biomarker in a small fish known as a Medaka that would signal exposure to endocrines. From the basic science they developed the 'Glowing Medaka Test' which is a fast and low costs test for EDC that identifies previously unknown toxicities in consumer products ranging from cosmetics to baby nutrition. Having licensed the transgenic Medaka technology from City University, a biotechnology company now offers the Glowing Medaka Test as part of its testing platform. During the RAE 2020 assessment period, the test has generated a major impact on consumer safety and animal welfare, regionally, nationally and globally. Today, it is used by several multinational cosmetics and food groups and by NGOs to ensure product safety and to inform customer choice. For instance, the World Green Organisation, a Hong Kong based NGO, set up Hong Kong's first Whitelist for Pregnancy Supplements and Baby Product, listing those products that have passed the test.

Sustainable agricultural practices

In addition to identifying environmental pollution, there was a small number of ICS that looked at natural interventions or technological ones to conserve the environment, especially in the context of sustainable agriculture. For example, researchers from Hong Kong Baptist University developed a unique irrigation method for growing rice. The lead researcher had observed in his childhood that on his family's small rice plot when there was virtually no irrigation after flowering there typically a better yield than usual. Inspired by this observation and research on wheat production, the research team developed and tested the Alternate Wetting and Drying (AWD) irrigation technique for practical use during the entire rice growing season. The effect of this method is the better utilisation of pre-stored carbon reserves in the rice stem for grain filling i.e. the final stage in rice growth that determines the final weight of the rice grain. Application of this method has been shown to lead to about a 10% increase in grain yield and a 30% reduction in water use. The most reliably quantified impact is from Jiangsu Province, China, where adoption of this method has led to an increased income of over RMB 4 billion (US$600m) for the participating farmers.

Another agriculture example came from The Chinese University of Hong Kong who has developed salt and drought-tolerant soybeans. The impact on sustainable farming practices was underpinned by genomic research on soybeans which resulted in both the whole genome being sequenced and from that specific traits being identified including, for example, salt tolerance. The research findings have been used in national projects to expedite the screening of new stress-tolerant soybeans.

With marker-assisted selection for the salt tolerance gene and field performance for drought tolerance, the team successfully developed 3 new salt and drought-tolerant soybean cultivars, namely Longhuang 1, 2, and 3. Today, in Gansu Province, China, the estimated accumulated acreages of Longhuang 1, 2 and 3 exceeds 12,400 hectares (2016-2019) with an estimated financial benefit of RMB 3.12m (US$476m). In addition to the financial benefit there are also environmental impacts through the reduction of fertilizer use and thus CO2 emission.

Community building

A final ICS continues with the theme of sustainable agriculture but applies to social cohesion and community building through the creation of a Community Kitchen and Guesthouse. The research focused on the challenge of how best to support the 'left behind' rural community in Mainland China, resulting in a project that combined elements of action research and participatory design, led by researchers from The Hong Kong Polytechnic University. The aim of the project was to address both economic and social problems by developing sustainable alternative income streams and through building mechanisms to improve cohesion in the socially fragmented village. Working closely with the residents, the cross-disciplinary team of researchers created a Community Kitchen and Guesthouse helping villagers learn new skills, diversify income sources, and self-organise. Within this RAE period through these 2 projects over HK$96k (US$12k) of new income has been generated, supporting community education and healthcare for all 150 villagers. This project's success has led to further rural community revitalization projects in 9 other villages, bringing social and economic benefits to over 2,000 villagers.

The characteristics and translation of the underpinning research

Table B provides the salient features of the underpinning research. It provides bibliometrics as well as information on the impetus for the research and mechanisms/channels of dissemination.

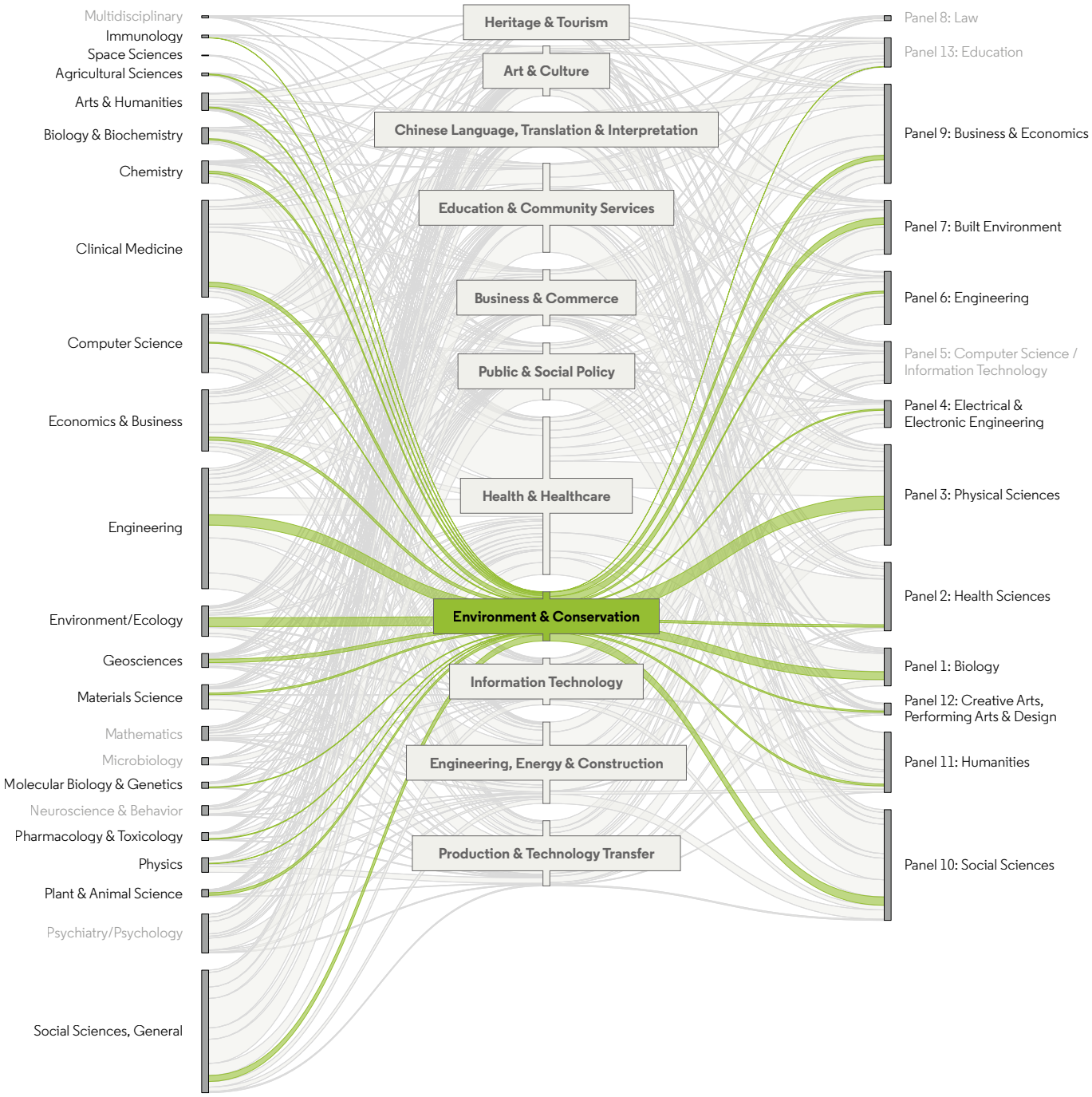
130 outputs from this cluster are indexed on the Web of Science, which have a mean citation score of 3.7. The median citation score is 2.21, which is higher than the median of 1.59 for all case studies. Key international collaborators included the United States (15%), Japan (7%), and the UK (6%). 12% of the research in this cluster was commissioned. The main forms of co-production and collaboration were academic and industry partnership (12%) and academic and public sector partnership (12%). The researcher was involved in the impact by being referenced as an expert or advisor (24%) and by having their research output cited by the sector (4%). The research findings were disseminated primarily media coverage (48%) and educational and training materials (44%). The research was often awarded prizes and awards (44%) and many of the resulting ideas or products were patented (16%).

Table B: Some salient features of research impact identified in the Environment & Conservation cluster (n = 25)

Analysis of underpinning research	**Cluster impact case studies**	**All impact case studies**
Bibliometrics indicators		
Number of outputs indexed on Web of Science	130	1445
Mean citation score	3.7	4.45
Median citation score	2.21	1.59
Collaborators location (top mentions, excluding China)		
USA	15%	18%
Japan	7%	2%
UK	6%	8%
Impetus for research (top two mentions)	**% of cluster impact case studies**	**% of all impact case studies**
Pull factors		
Commissioned	12%	16%
Mechanisms/channels of impact (top mentions)	**% of cluster impact case studies**	**% of all impact case studies**
Coproduction & collaboration		
Academic - industry partnership	12%	23%
Academic - public sector partnership	12%	17%
Researcher involvement		
Referenced as expert, practitioner or adviser	24%	33%
Published output cited by sector	4%	11%
Dissemination of research findings		
Media coverage	48%	48%
Educational and training materials	44%	32%
Codification of impact eg prizes, patents etc.		
Prizes and awards	44%	33%
Idea/product patented	16%	11%

The alluvial diagram in Figure 2 links the underpinning research (as classified by discipline using the 23 Web of Science, Essential Science Indicators (ESI), journal categories) to the 11 clusters identified through the topic modelling and the 13 Panels used in RAE 2020. The Environment & Conservation cluster has been highlighted, with the impact pathways for the other clusters greyed out. Figure 2 illustrates the multidisciplinary nature of research impact; multiple journal categories feed into the cluster and the cluster contributes to ICS submitted to a range of RAE panels.

Figure 2: Alluvial diagram linking underpinning research with clusters and panels.



Methodological annex

This synthesised impact report presents a cross-cases analysis of the salient features in 342 impact case studies (ICS) provided by Hong Kong universities as part of the RAE 2020 evaluation. A sequential multi-method approach was employed. The first component involved quantitative topic modelling, followed by directed content analysis. This approach allowed the essence of the impact generated by Hong Kong universities to be captured and synthesised. It is important to note that the analysis and conclusions of these reports are based on the impact as described in the ICS. That is, the authors of this report took the case studies at face value and did not verify or question the narratives provided. A summary of the methodology is given below. For more detailed information on the methodological elements of this study, please see the overarching impact report.

Quantitative topic modelling

Quantitative topic modelling was used to identify overarching topics in the ICS. Topic modelling is a language processing technique applied to document sets to understand the different combinations of words or phrases (topics) that are present. It is a data driven approach, meaning results are not dependent on pre-conceived notions of structure, but are instead derived from the data itself.

Python, Scikit Learn, and Gensim packages were used to implement the topic modelling. Text from section 4 (Details of Impact) from the ICS was normalized (i.e. removal of punctuation and special characters), and domain specific stop-words were removed (i.e. words that are used frequently across the case studies). Various implementations of the topic modelling algorithm were tested, and the Non-negative matrix factorization [NMF] was found to produce the most usable results. After testing multiple models using this algorithm, and manual review by the authors, the number of topics was set to 35 to provide a balance between the breadth of groupings and granularity of topics.

In discussion with UGC, the research team developed an initial taxonomy by grouping similar topics into broader ‘clusters’. For example, the topics ‘finance’, ‘accountancy and governance’, and ‘economics’ were grouped into a cluster titled ‘business & commerce’. Topic clusters were set at the outset of the analysis to ensure cognitively similar cases were read together, thereby improving the quality of coding, analysis, and impact reports. This classification system then informed the coding and testing of case studies.

Directed content analysis

Qualitative directed content analysis was then used to elucidate the salient characteristics of the impact narratives. This involved an iterative process of examining case studies and developing a code book to categorise their inherent features. The code book was derived from the existing literature and the domain expertise of the authors. It included four overarching categories: a) research, which captured funding source and impetus for research; b) time lags, which captured the elapsed time between the research and its impact; c) mechanisms/channels of impact, which included forms of collaboration and dissemination; and d) impact, which included beneficiary groups (e.g. young people, women, ethnic minorities), location and reach (e.g. Hong Kong, Mainland China, elsewhere), and the nature of impact (e.g. commercial, policy, practice).

Using the cloud based qualitative analysis software, Dedoose, each case study was read, and relevant excerpts were 'tagged' with the relevant codes. Multiple codes and subcodes were attributed to individual case studies. This allowed all case studies that had been tagged with a particular code (e.g. a particular beneficiary group) to be considered as a group. Two of the study's authors undertook the reading and coding (JG and KW). Inter coder reliability was ensured by double coding 10% of the cases (i.e. each author codes the same case study) and through regular coding meetings that were used to compare code applications and adjust the code book as required. The code book was thus a 'living document' that was reviewed and revised iteratively. This process allowed for cross case analysis that was the basis of synthesised impact reports. A code co-occurrence matrix was used to identify where the overarching codes intersect (for example, instances where particular topics are associated with particular beneficiary groups). The properties of the ICS were systematically examined, and evidence was gathered by assigning segments of text to unique codes within the broader coding categories. This process allowed for cross case analysis that formed the basis of this synthesised impact report.

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