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The impact of universities on climate change: a theoretical framework

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Contents

Abstract 4

Introduction 5

Characteristics of climate change 9

Universities: an anatomical overview 15

A framework of university impact on climate change 23

Mitigation and adaptation pathways 26

Characteristics of the model.....31

Conclusion 35

Acknowledgements.....39

References 40

The impact of universities on climate change: a theoretical framework

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Abstract

Universities have a crucial role to play in addressing climate change, but the complexity and multifaceted nature of the issue presents challenges for the traditional functioning of the institution. While there is a growing body of work on campus sustainability and climate issues in the curriculum, there is a need to understand more holistically the forms of influence that universities have on society and the environment. This paper puts forward a framework for understanding the impact of universities on climate change, involving four stages: the modalities of university action (education, knowledge production, public engagement, service delivery and campus operations); direct engagement with bridging actors; the broader influence on societal understandings and practices; and finally impact on the ecosphere. Specific pathways of impact are identified, involving either mitigation of or adaptation to climate change. This framework serves as an analytical tool to identify the trajectories of impact already in evidence, but also presents normative implications for the role of higher education institutions in addressing the current climate crisis.

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Introduction

The story of climate change is closely entwined with the university. Unusually, given the intensely political nature of the issue, scientists have been key protagonists, not only as members of authoritative bodies such as the Intergovernmental Panel on Climate Change (IPCC), but also as whistle-blowers, campaigners and champions of the cause (and consequently targets of vilification by the climate denial lobby). While much climate science takes place outside of universities – in specialised institutes, or state bodies such as NASA and the Met Office - the higher education system is still the pre-eminent locus for generation, communication and validation of knowledge on the issue.

Yet the relationship between the university and climate change is highly complex. Universities are not only sites for creation of knowledge in the Humboldtian vein, but also institutions of teaching and learning, of formation of professionals, of services provided to communities and government, and are micro-societies and economies in their own right. These varied functions and roles have diverse and sometimes contradictory interactions with climate change, and with its immediate and root causes. Given the multi-faceted nature of anthropogenic global warming, all of these functions will need to be engaged if the university is going to contribute substantially to addressing it.

Furthermore, the uncomfortable truth is that the impact of the university is unpredictable, and not always positive. University-educated people are most likely to believe in and act on climate change (e.g. Phillips et al. 2018), but there is no guarantee in this regard, and there are many degree-holding climate change deniers. As Cortese (2003: 16) states: “Indeed, it is the people coming out of the world’s best colleges and universities that are leading us down the current unhealthy, inequitable, and unsustainable path”. While university-based scientists contribute to understanding of greenhouse gases and development of renewable energy, they are also implicated in development of the science and technology that is enabling continuing exploitation and usage of fossil fuels. Universities also contribute significantly to emissions through their own energy usage, their investments and the

extensive travel of their staff and students (Shields 2019). In summary, universities have extraordinary potential for contributing to sustainable development and addressing the root causes of climate change, yet that contribution is not guaranteed, and requires close understanding of the institution and its complex interactions with society.

This working paper aims to explore this relationship. It poses the question, how can the impact of universities on climate change be understood? And on the basis of that knowledge, what should universities do about it? Many of those working in universities, along with university leaders and policymakers, are seeking to make their institutions agents of positive change in relation to climate and the environment more broadly. Yet very often the initiatives taken are restricted to a narrow range of functions. There are complex questions to be addressed of where emphasis should be placed, in teaching, research or other aspects of the university's work, of how to avoid 'silo' working, and of what kinds of influence different forms of action will bring on society and environment.

The primary objective this working paper then is to provide a conceptual mapping of the various functions of the university and the pathways through which they might impact climate change. It also assesses how the different configurations of those functions and interrelationships might affect the potential positive role of universities in addressing the climate crisis. The second objective is to draw out a set of normative implications for changes needed in universities and higher education systems if they are to fulfil their potential. The theoretical framework also provides pointers for researchers, highlighting areas in which empirical studies have been scarce to date.

Existing literature on universities and climate change has focused primarily on greening the campus (e.g. Atherton & Giurco 2011; Benayas et al. 2010) and incorporating issues into the curriculum (e.g. Leal Filho 2010; Molthan-Hill et al. 2019; Fahey 2012). An immediate need, therefore, is to expand the discussion to include a broader range of functions of higher education, and the interactions between them. Some accounts of the role of universities in climate change and

sustainable development (e.g. Cortese 2003; Henderson et al. 2017; Liu & Kitamura 2019; Vaughter et al. 2013; Wals & Blewitt 2010) have specified the constituent elements of the university (education, research, outreach etc.) and emphasised the need for integration between these different elements. Yet it is necessary also to explore and theorise the trajectories of these forms of action, and their impacts on the society and the ecosphere. In doing so, this paper draws on broader frameworks and theories of university impact on development (e.g. Brennan et al. 2004; Castells 1994; Cloete et al. 2011; Fehlner 2019; Oketch et al. 2014). It puts forward an original scheme specifically in relation to climate change, but with implications for the general relationship between university and society.

In this task, the paper takes as a starting point some of the theoretical considerations put forward in McCowan (2019) in relation to universities' role in achieving the Sustainable Development Goals (SDGs), in particular the notions of projective and expressive roles, and the five modalities of education, knowledge production, public debate, service delivery and embodiment. These fledgling ideas are filled out, and applied to climate change specifically, which has some elements that are distinctive in relation to the broader notion of sustainable development. These considerations lead towards the proposal of a new framework for understanding the trajectories of impact, involving 15 distinct pathways.

This paper forms part of the *Transforming Universities for a Changing Climate* research project, which explores the impact of locally generated university initiatives on climate change in Brazil, Fiji, Kenya and Mozambique. The broader project adopts a participatory action research design to implement and monitor interventions relating to mitigation and adaptation to climate change, involving local communities, university students and public engagement at the national level. This paper provides a conceptual mapping that will frame the analysis of the empirical data generated from the project, and aid in understanding the impacts and potentialities of universities.

There is a political economy analysis needed to explore the extent to which universities are actually addressing the challenges of climate change, the reasons

for their action or inaction, and the variation across different types of institution and countries. There are currently global trends that both drive and impede meaningful action in relation to this issue – including marketisation, the rise of international university rankings, emphasis on demonstrable social and economic impact, expansion of for-profit and distance providers, amongst others. It will not be possible to address all these questions in the current paper, and they require separate treatment. This paper focuses on the configurations of action and interaction within universities and between universities and climate change, on which these political economy influences then act.

The term 'university' is utilised in this paper to indicate an institution of higher education that engages in teaching, research and public service (although acknowledging that the balance between these activities and the content of them may vary considerably). Most institutions of tertiary education in the world today do not adhere to this profile, and operate on a teaching-only basis, without full-time staff and campuses on which broader learning and scholarship might take place. While not all aspects of the analysis will therefore be relevant to teaching-only institutions, there are implications for the curriculum, the pedagogical model and the management of institutions that apply to the whole post-secondary sector.

Finally, there is the notion of impact. This idea has become a buzzword in higher education in recent years, as part of initiatives to encourage stronger ties between university and economy/society, and the practical and immediate relevance of research – notably in the UK, in which it has been adopted as an important part of research evaluation (Martin, B. 2011; McCowan 2018; Oancea 2013). There are complex debates about the appropriate level and form of interconnection between universities and the outside world, and the extent to which societal changes can be attributable to the university (Ashwin 2016; Fielding 2003; Martin, C. 2011), and these will not be the main focus of this paper. For the purposes of this analysis, impact will be understood in the broadest terms, in the words of Findler et al. (2019a: 25) "the effects that an HEI[1] has outside of its organizational or academic

[1] Higher education institution

boundaries". These effects can be intended or unintended, and in some cases (including some outlined in this paper) extremely hard to measure. These difficulties of measurement and attribution, as well as the unpredictability of the process, should not dissuade us from taking seriously the full range of potential impacts of the university, and striving to achieve them.

The next section will assess the characteristics of climate change, and highlight its complex and multifaceted nature, presenting particular implications for higher education. Following that, there is an assessment of the university as an institution, and the constituent parts that might contribute to addressing climate change. This analysis leads then to the proposal of a framework for understanding the impact of the university on climate change, along with an identification of 15 pathways of influence. Finally, implications are drawn out for higher education policy and practice in the contemporary age.

Characteristics of climate change

Climate change, in its current usage, is a shorthand term that refers to those changes in the earth's climate attributable to human beings in the contemporary era, involving an overall increase in temperatures and other environmental effects. Anthropogenic global warming is caused primarily by emission of fossil fuels, most important amongst these carbon dioxide, which trap heat in the earth's atmosphere. This warming is problematic for humanity for a variety of reasons, including rising sea levels, disruption of agriculture, extreme weather and loss of biodiversity (Anderson 2012; Berners-Lee 2019; Klein 2014, 2019).

Climate change is frequently described as a 'wicked problem'. Unlike conventional 'tame' problems, wicked problems cannot be solved by a technical 'engineering' approach, as they are complex, resist clear definition, are grounded in value perspectives, and have innumerable potential solutions that cannot be pre-tested (Head & Alford 2013; Rittel & Webber 1973). The causes of climate change are multiple, its impacts are gradual and not easily attributable, and interventions in one

area may bring unexpected changes in another area. Climate change has even been designated a ‘super wicked’ problem, with four characteristics:

> time is running out; those who cause the problem also seek to provide a solution; the central authority needed to address them is weak or non-existent; and irrational discounting occurs that pushes responses into the future. (Levin et al. 2012: 124).

Furthermore, climate change is urgent and time bound. Most commentators assert that radical action needs to be taken by governments and societies now, or we will reach the ‘tipping point’, at which climate change and its destructive impacts becomes rapid and irreversible, on account of the multiple feedback loops. The IPCC – which tends to have a conservative and less alarmist position on these matters – stated in its special report (IPCC 2018) that the world needs to convert entirely to renewables by 2050 to avoid a catastrophic temperature rise of 2°C. Given the cumulative nature of the impact of greenhouse gases, the later that we leave mitigating action, the more difficult it will be to achieve.

This working paper does not attempt to put forward a distinctive position on the environmental aspects of climate change, the movements of global temperatures, their causes and likely future trajectories. That task has been amply addressed through the IPCC and many other climate scientists around the world. The task of this paper is to draw out the implications of this scenario – with all its uncertainties and contestations – for the work of the university.
A crucial distinction for understanding responses to climate change is that between mitigation and adaptation:

> Mitigation objectives address the causes of climate change, whereas adaptation objectives address the impacts of climate change through an adjustment in natural or human systems in response to the actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. (Alves et al. 2020: 193)

The kinds of actions involved in mitigation and adaptation are likely to be very different. Mitigation involves lessening the direct contribution of universities to climate change (through greenhouse gas emissions, investments in fossil fuel companies etc.), developing research and innovation in relation to fuel efficiency, carbon capture etc. and changing the mindsets of students so as to encourage climate-friendly actions in their later lives. Adaptation, which is connected to ideas of preparedness and resilience (Holloway & Fortune 2018; Kitagawa 2017; Preston et al. 2015), will involve application of knowledge to address required changes in lifestyles, agriculture, housing, healthcare and so forth, both in relation to capacity building and awareness raising, but also generation of new ideas and technologies. Adaptation should not, however, imply surrender in the face of insurmountable odds, or a politically disempowering acceptance of the *status quo*: it is not an alternative to mitigation, but stands alongside it. Even as we transform our societies towards a more sustainable future, we will still need to adapt to changes in the climate already underway.

All universities have some responsibilities in relation to adaptation and mitigation, both in relation to themselves as institutions with their own communities, and in assisting communities in the society outside of them. Yet there are geopolitical differences here: universities located in wealthy neighbourhoods and in high income countries may have a greater responsibility in relation to mitigation, as their local/national communities are likely to be disproportionately contributing to greenhouse gas emissions. Conversely, those universities located in lower income areas and countries may have to work harder in relation to adaptation, as their populations are likely to be disproportionately affected by the adverse impacts of climate change, and have fewer resources with which to combat them. Having said this, the pressures of economic growth at all costs are also strong in lower income countries, and climate change impacts will be evident everywhere, so both mitigation and adaptation are necessary in all contexts.

One key aspect of climate change in relation to the role of universities is its anthropogenic nature. While the movements of the climate are the result of the interaction of a number of factors, the vast majority of climate scientists attribute the

recent increases in average temperatures to human causes (Oreskes 2004). The greenhouse gas emissions that are the direct cause are themselves rooted in the growth of industry, fuelled by consumerism and the capitalist system, and in turn by the separation of humankind from the rest of nature, and the exploitation of the latter by the former. The solutions, therefore, are also rooted in human societies, and constrained by a range of psychological, political, economic and cultural factors. The relevance for the university here is that understanding the causes and impacts of climate change involves not only the full range of life sciences, physical sciences, engineering and technology, but also economics, social sciences, arts and humanities (Leal Filho et al. 2018).

Climate change is also characterised by complexity. Climate is a ‘complex’ rather than a ‘complicated’ system as it is not just made up of a large number of elements interacting in intricate ways, but has inherent unpredictability, and no clear chain of cause and effect (Tikly 2019). Complex systems are also characterised by *autopoiesis* – literally, self-production, or self-organisation, referring to their ability to maintain themselves through adapting to changing circumstances; and by *emergence* – the appearance of new characteristics and dynamics as a result of the interaction of constituent parts. There are many factors at play in the climate system – including the sun, but also the earth’s atmosphere, the earth itself, the oceans, ice, plant and animal life – and aspects of their interaction that are hard to identify and predict. Denial of anthropogenic global warming has been aided by the fact that the earth’s climate has changed repeatedly in past millennia on account of natural causes. Most contemporary scientists working on questions of climate are convinced that temperatures are being increased through human activity, yet there is still some uncertainty as to the speed of those changes, the impacts and the interventions that might mitigate them.

Solutions for the crisis are hard to identify, not only because they require multisectoral action, but because we cannot always be sure whether interventions in one area will not bring unexpected outcomes in another (Leal Filho et al. 2018). There is widespread concern about geo-engineering interventions such as use of aerosols to block the sun’s rays, on account of the potential knock-on impacts on

other aspects of the environment such as monsoon rains (Klein 2014). Berners-Lee (2019) discusses the disheartening phenomenon of rebound effects, through which efficiency gains in energy usage have led not to decreased usage of fuels, but to increased energy consumption. These elements of complexity are central to the 'wicked' or 'super wicked' designation of the climate crisis.

Given its political ramifications, one would expect climate change to be controversial, but it is particularly noteworthy in this regard. Climate change is contested in three ways: in its facts, in the strategies to address it, and in the normative questions it mobilises. It is well known that despite the large number of scientists asserting the existence of anthropogenic global warming, there are a number of contrary voices (e.g. Booker 2009; Lomborg 2007; Morano 2018). Some of these argue that temperatures are not rising at all, others that they are rising but due to natural not human-made reasons, and others that anthropogenic global warming is a reality, but that the impacts will not be severe as made out by the likes of Al Gore and his *Inconvenient Truth*. These disputes have been intensified by the epistemic polarisation, the fuelling of distrust of experts and questioning of scientific knowledge in the 'post truth' era.

Even amongst those who do recognise the reality of global warming, there is significant contestation over what should be done about it. Some see technology as the answer, in part resting on the faith in future technological advances in the areas of carbon capture or geo-engineering. Others (including most environmental organisations) see that reduction in emissions is essential, and most governments recognise the need for a movement towards renewable energy sources. Some (e.g. Orr 1994) go much further than this position and argue for the need for a veritable paradigm shift for human society, a move away from consumerism and the forging of a new relationship with the natural world, of harmony and non-exploitation. These different responses are closely linked to an understanding of the problem as primarily scientific, or one that is more strongly rooted in society, in politics, economics and culture – but they are also predicated on diverging values of a moral, political and even aesthetic nature (Marshall 2014).

The characteristics outlined above present two major implications for the university. The first is, simply, that it is ideally placed – possibly even essential – to addressing climate change. As stated above, climate scientists are largely (though not exclusively) located in higher education institutions, and the lion's share of our knowledge on the issue stems from the work of universities. Universities and their staff also have a unique role in applying theoretical knowledge to practical questions of mitigation and adaptation, working together with government, private sector and civil society organisations. The changes in understanding and behaviour in the population as a whole also position the university as a crucial site of education, in conjunction with schools of course (Facer 2019). Finally, as an institution that is oriented not only towards generation of knowledge, but also in questioning, debating and determining the basis of our knowledge, it is also well placed to address the epistemic challenges of the issue – and can intervene directly in that sphere through its teaching function.

The second implication relates to the ways in which universities should address the issue of climate change. The central place at the table given to the university in these debates does not mean that its traditional ways of working will be up to the task. Climate science involves interdisciplinary working that presents challenges to subject-based structures, traditions and taught courses (Leal Filho et al. 2018). Researchers are also forced to engage with political issues and currents in ways that may make them uncomfortable. Furthermore, and as argued in the section that follows, there will need to be a more holistic understanding of the workings of the institution, and the interlinkages between research, teaching, community engagement and other functions.

Universities: an anatomical overview

We normally think of educational institutions as preparation for life – that is, life after or outside the school or university. In them, we acquire a set of skills, say reading and writing, or speaking basic Spanish, that we will be able to apply in situations outside the school – in accessing health information, or working with tourists from Chile. Alternatively, education may involve acquiring specialised bodies of knowledge that we will utilise directly, say of pharmacy or architecture. In most cases – though not always explicitly – educational institutions also aim to instil a set of values – whether of hard work, independence of thought, adherence to a national ideology, competition or cooperation. In all of these examples, the school is serving as a conduit; it is a waystation, a training ground for preparation for the real life which waits beyond it. We can term this the *projective* function of education institutions (McCowan 2019). It is the most commonly invoked, and sometimes the only way in which they are conceptualised.

Yet we can also see educational institutions as having an *expressive* function. In this case, they are arenas of society in their own right, spaces in which skills, knowledge and values are being utilised as well as acquired, and in which there are significant human interactions and dynamics. Universities in this way are like towns or villages, and in some cases cities – Latin American universities such as the National University of Mexico or the University of Buenos Aires have as many as half a million students and staff on campus. It matters in this way what happens during the educational experience, and not just what happens after it, or outside of it.

This distinction is close to that between *process* and *outcome* conceptions of educational quality (Alexander 2008; McCowan 2013). The quality of schools in the contemporary era is for the most part gauged on the basis of outcomes, whether through national tests, or most prominently at the international level, the PISA assessment. This approach has gained popularity (displacing earlier emphases on inputs such as teacher qualifications, textbooks and facilities) as it gets at what children have actually learnt, and provides a degree of flexibility on the means adopted. However, looking solely at the outcomes of the venture entails ignoring the

means used to achieve them. Paradoxically we might even see these means as ends in themselves. The actual process of teaching and learning is important in addition to what is learnt at the end of the day: the moment of enquiry and understanding, the pedagogical encounter, can be seen as having value in itself.

The examples above have related to teaching, but we can see research in a similar light. We normally think about research through a projective lens: that is to say, researchers engage in a project of investigation, make a discovery, and share it with the outside world, sometimes with positive impact or practical application. In the era of emphasis on impact, these real-world applications have become particularly prominent (Oancea 2013). Yet we can also see research in a process sense. Enquiry is a practice in its own right, involving painstaking empirical investigation or conceptual exploration, with its own dynamics and values. In Collini's (2012) conception, this is the only way we can rightfully view research and scholarship, being an open and never-ending process. So research and scholarship can be viewed as practices, as an attitude or stance on life, as a lived experience, as well as a product – and they can be seen as having value, independently of any positive outcome accrued.

In a normative sense, it is important to observe the extent to which education institutions incorporate the values that they espouse within their own actions – to 'practice what they preach' so to speak. Cortese (2003) argues in this way for alignment between education, research, university operations and external community in the workings of the university: "a fully integrated community that models social and biological sustainability itself and in its interdependence with the local, regional, and global communities" (p.17). This idea can be conceptualised as institutional *embodiment* (McCowan 2019), referring to the degree of consonance between aims and actions, the harmonisation of the projective and the expressive. If we take the example of the SDGs, a university that purports to be aligning its work with the framework would need not only to be training gender specialists who will go on to work for international organisations, but also practising gender equality in its curriculum representations and treatment of staff (SDG5). It would need not only to be developing new forms of technology for solar panels, but using renewable energy

for its own operations (SDG13). Embodiment of these values within the everyday workings of the institution is conducive to the incorporation of those values in the lives of the students and staff within them; or conversely, we can say that promotion of values is unlikely to be successful when there is a patent contradiction between what the institution says and what it does. However, this process is not automatic, and in some cases environmentally unfriendly graduates may emerge from an environmentally friendly institution, and vice versa.

University activities can be divided in different ways, the most common being the triad of teaching, research and community engagement. In relation to climate change specifically, Henderson et al (2017) based their analysis around five domains: governance (institutional priorities, values and proclamations), education, campus operations, research and community outreach. Findler et al. (2019a), focusing on the broader area of sustainable development, identify five similar areas: education, research, outreach, campus operations and campus experiences, in addition to an integrative impact of the higher education institution as a whole. These schemes do not present major divergences, but highlight specific areas for emphasis. For the purposes of this paper, the university will be understood as having five modalities of action, as outlined in McCowan (2019): education, knowledge production, service delivery, public debate and campus operations. In this paper, the broader learning acquired by students designated by Findler et al. as ‘campus experiences’ is also included under ‘education’, while governance (outlined in Henderson et al. 2017) will not be considered a separate domain as it is understood as underpinning and expressing itself in relation to all of the areas.

The five modalities utilised in this paper are outlined in Figure 1, along with some examples of activity in each. The first two of the modalities correspond to the most recognisable ‘pillars’ of the university: teaching and research. The first, education, refers to the role of the university as a space for learning, and for personal, civic and professional development. It is the most prominent function of the university, and many higher education institutions only have this function. Knowledge production, on the other hand, involves not the transmission or facilitation of knowledge, but its generation, and normally arises from research and scholarship carried out by

academic staff, but in some instances also by students and community members. This modality includes not only basic and blue skies research, but also knowledge applied to the practical demands of government, industry and civil society organisations, the development of new forms of technology, and innovation more broadly.

In conventional categorisations, the third pillar of the university (in addition to teaching and research) is the least well-defined, and is variously known as service, community engagement, extension or third stream activities. It refers to those activities of the university that connect directly with external communities – i.e. not with its own staff or students. Here, these activities will be divided into two as they constitute very different types of work: service delivery and public engagement. In relation to the former, there are services delivered directly to communities, for example running a health or legal clinic that community members can access, monitoring levels of air pollution to provide information when it is unsafe to go out, or running a short course on business French. This category also includes services provided to government, organisations and business, such as consultancy and secondments.

Yet there is a broader set of public engagement activities that relate to debates in the public sphere, through the ideas put forward in formal research outputs such as journal articles, which filter their way through the media into public discussion, or through the direct engagements of staff in the media or social media. In some cases, universities will have their own media outlets such as newsletters, blogs, radio, and even television stations.

This modality can also express itself through the political involvement of staff and students, their participation in campaigns and protests, and in other forms of direct action. Universities can also serve as sites (either physical or virtual) for hosting and encouraging deliberation and debate, as discussed by Marginson (2011) in relation to the ‘public sphere’ mode of the public good.

The level of influence that universities have on public debate differs markedly between universities, between countries and from epoque to epoque, and is very hard to gauge, but undoubtedly represents a significant influence of the institution on society[2].

There is a sphere of university activity which does not represent the core purpose of the institution, but is nevertheless very relevant to climate change, and that is its operations as an institution and as a campus. As a community and as an organisation, the university manages its finances, its human resources, purchases equipment, uses fuel, sells food and merchandise, in some cases makes investments, and all of these activities have implications in terms of mitigation and adaptation of climate change. In some cases, universities own land beyond their immediate campuses, and make decisions about the usage of that land, for agriculture, forestry or commercial developments. In this category we would also include the travel undertaken by international students, a significant source of carbon emissions: while this might appear to be within the 'education' category, it is not strictly a result of the teaching and learning itself, but of the logistical organisation of the institution and its members. For some institutions the goal in terms of campus operations is to become carbon neutral or net zero – which can involve not only reducing emissions, but also offsetting through carbon credits or sequestering carbon.

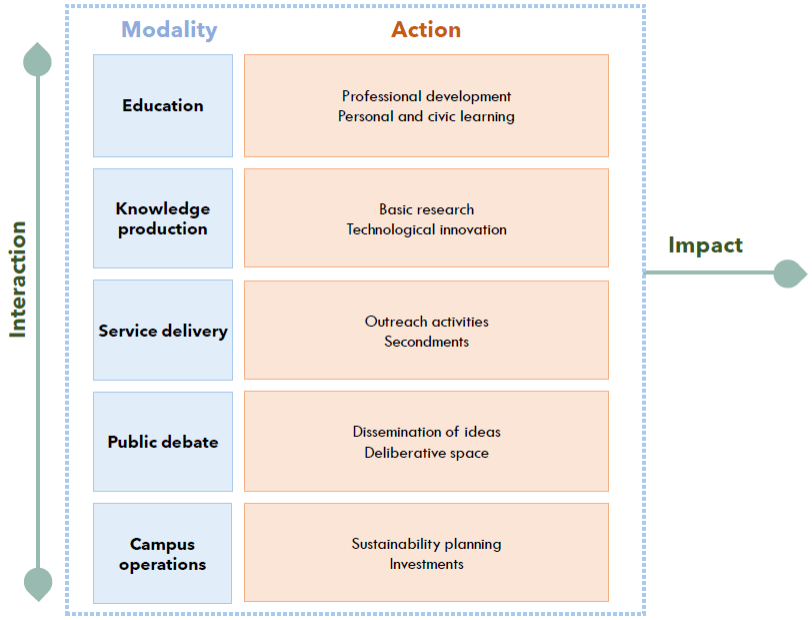
This frame of the projective and expressive can be used in relation to all of the five modalities of the university. The modalities of education and knowledge production have already been discussed above: teaching and research normally project themselves towards future goals, but can also be an instantiation of those goals (say of gender equality). Service delivery and public engagement in the projective mode are also oriented towards external objectives – bringing a particular positive change in society, but in expressive mode, they can be seen as intrinsically worthwhile

[2] There are some areas of ambiguity here: massive open online courses (MOOCs) represent a liminal case, as they might be considered either education or public engagement. If the MOOC is part of a formal taught course, then it is more appropriate to consider education, and if made available on open access for all, without assessment, then public engagement – but it is acknowledged that there are in all cases blurred lines between these categories.

activities, through engagement in critical enquiry and respectful, mutually nourishing human interaction. While it is harder to apply the frame of expressive and projective to campus operations, we can see these institutional operations as having a procedural existence – the process, principles and experience of running the institution, of management and leadership – as well as a set of outcomes – the impact of decisions taken on the outside society.

The five modalities are represented in the figure below:

Figure 1: University Modalities



For each of these five modalities, it is important to observe three characteristics: the *action* itself, and specifically the nature and extent of activity undertaken within each modality; the *interaction* between them; and the *impact* they have on the society outside. The most straightforward of these characteristics is the first. We can identify the extent to which institutions carry out particular actions: for example, an institution may be involved predominantly in education, or it may be a research organisation, but with graduate-level courses. Some universities have extensive work in the area of delivery of services to community and public engagement. The nature of these activities also differs markedly. There will be different focal points, involving various actors and underpinned by diverse values. Crucial here is the extent to which the

modalities are oriented towards public and private good (Marginson 2011, 2018; Singh 2012; Unterhalter et al. 2017), and in relation to climate change specifically, the extent to which those actions are relevant to adaptation to and mitigation of climate change.

The second characteristic concerns the interactions between these elements. An institution may have greater or lesser porosity between these different activities (McCowan 2019). Most commonly discussed is the teaching-research nexus, the extent to which lecturers incorporate their research findings into the taught courses, or alternatively the opportunities available for students to participate directly in and benefit from research projects. Community engagement work, either of the service delivery or public debate type, can also draw to a greater or lesser extent on research and scholarship carried out within the university. The fifth modality of campus operations will necessarily have a very high level of interaction with the others, since by its very nature it underpins all of the core functions of the university.

There may exist hierarchies or power disparities between these different areas. Research has pride of place in the contemporary elite university, bolstered by the weightings of elements in the international university rankings. Community engagement in its different forms usually occupies a subordinate position, either with a posture of beneficence towards the less enlightened external world that finds space when academics have time, or with a commercial orientation aiming to generate income for the institution. Some more subversive approaches may attempt to revert that imbalance, so for example in Santos's (2004) ideas of counter-extension, in which the university draws on and learns from the knowledge from the community. In some cases, the university be may be in a subordinate position to the external 'community' when the actor in question is a government or powerful corporation, and is its paymaster.

There may also be different types of interaction – it may be a simple sharing or diffusion of material from one to the other. So, for example, a new technique for low-cost water purification developed within the university may be rolled out to surrounding slum areas. Yet in other cases the value of the interaction may be

greater than the constituent parties: so, it may be that it only became possible to develop the low-cost water purifier through the engagement work between scientists and community members, drawing on the experience of both.

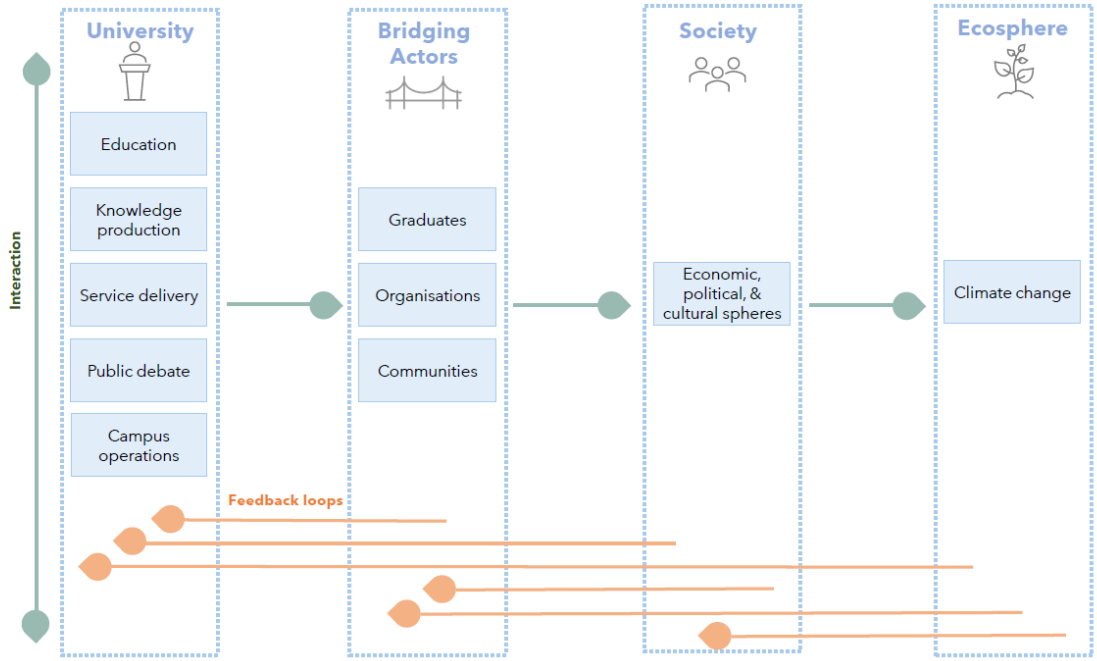
Finally, there is impact. This element concerns the outcomes of a particular activity: for example, the effect of an undergraduate course on the life and work of a graduate, or the changes in society resulting from research in biochemistry or anthropology. There is a high degree of complexity in gauging impact, in the first place due to challenges of tracking and attribution (McCowan 2018). We would expect a history graduate to have developed a set of positive values, knowledge and skills through her studies, and that those qualities would positively influence her life, her work and her interactions with others subsequently. Yet it would be almost impossible to fully gauge the millions of interactions she will have with others through the course of her life. Second, it is not easy to attribute changes that are observed in the outer society directly to the influence of the university. While a history graduate may be using documentary analysis and critical thinking skills in her environmental work as a civil servant, it is hard to say what is the impact of the university, and what is the impact of her previous schooling, her spare time reading, interactions with family and so forth.

So the impact of the university in these diverse areas is extremely hard to gauge with any precision. Nevertheless, it is important that we attempt to do so, while acknowledging that any endeavour of this sort will be an approximation. The following section outlines an attempt to understand this dimension in greater detail, and outline the pathways to impact of the university, relating them specifically to climate change.

A framework of university impact on climate change

The visual model (figure 2) representing the trajectories of impact contains four stages, starting with the university itself, divided into the five modalities outlined in the previous section. It shows the general movement of impact of the university on society and natural environment from left to right of the diagram, as well as the feedback loops from right to left, indicating the effects of the environment on society, and of society on the university.

Figure 2: Stages of Impact



The stage of ‘university’ involves primarily the actions of its members – staff and students – but also those of the institution itself – its organisational structures, carbon emissions and investments. After the university modalities, come ‘bridging actors’: these are the groups outside the university that have or have had direct interaction with it. Most obvious of these, and by far the most numerous, is the former student population, which having left the university and gone out into the world are categorised as ‘graduates’. Universities also have direct contact with external communities including businesses, government and members of the local community through their research and community engagement work. Universities

deliver services to these organisations through consultancy work, running projects, industrial collaboration, writing reports, seconding staff members and so forth. Some organisations also commission research from universities – though this is normally limited to businesses, large charities and government departments. These actors are designated bridges since in addition to receiving impact themselves, they also serve as conduits of impact to the broader society.

The next stage is that of society as a whole. In this case, it is not a question of contact between the university and specific people, groups or organisations. Instead, it is a more diffuse interaction of ideas, products and influences, one that is harder to chart and attribute. So, for example, the university may develop a vaccine that is adopted for general use, or achieve a breakthrough in mathematics that influences a new generation of computers used at home and in the workplace. In this case the impact goes straight from knowledge production to society, highlighting that these benefits occur, even when individuals have not been directly involved in the process or commissioning of research. In other cases, it may be a question of 'knock-on' impact, going via the bridging actors stage – so for example, when others are subsequently influenced by the work of professionals who have been trained in universities. (These different trajectories will be outlined more fully below in Figure 3).

The education modality, therefore, influences society as a whole, even those who have not attended university. This occurs through the knock-on effects of the learning acquired by graduates, primarily through their employment, but also through their civic participation and personal lives. So, all people benefit from the teaching and learning taking place in university through the subsequent work of doctors, engineers and social workers. There is extensive empirical evidence (e.g. McMahon 2009; Bynner et al. 2003, Oketch et al. 2014) showing the general impacts of graduates on society in the areas of stronger support for democracy, human rights and environmental protection, lower crime rates, gender equality and better nutrition and health.

Universities also have impact on society through public engagement activities. In some cases these may be closely related with knowledge production: for example, media discussions of research that has been carried out, or popular books and television programmes on science of the kind produced by Richard Dawkins and Brian Cox in the UK. In other cases they may not be directly connected with research carried out in the university, and may involve political opinion expressed through social media or formal media channels, and other commentary on society, with some academics taking on roles as ‘public intellectuals’.

The influences of the university on society at this stage may involve concrete changes in the lives of individuals (protection against an infectious disease), or shifts in their thinking (understanding of the impact of livestock farming on greenhouse gas emission). Yet it may also contribute in a more diffuse way to the constitution of economic, political and cultural structures in society, influencing norms and social practices, as well as policies and institutions.

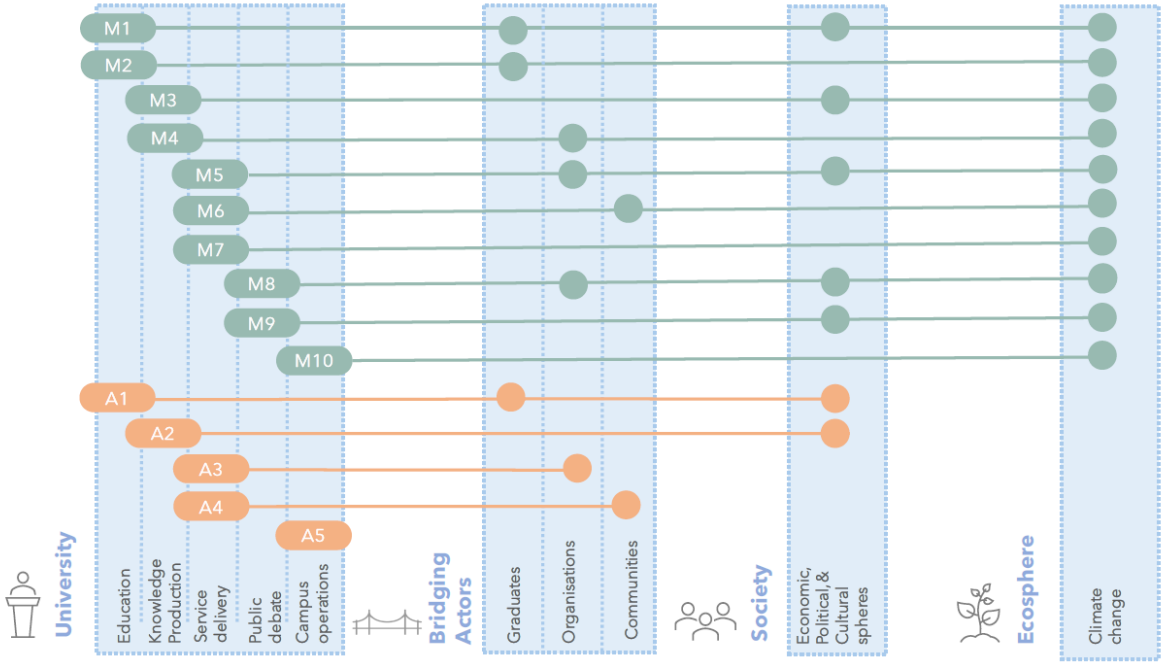
Finally, there is the fourth stage, the ecosphere. Here the emphasis moves from human societies to the natural world, and the influence that the former has on the latter. For the most part, the influence is mediated by the communities that have direct contact with universities, and the knock-on impacts on society, i.e. via stages two and three. In some cases there are direct impacts, for example through campus operations, the effects of energy usage, recycling, procurement policy, and so forth. It is important to point out that the impacts at this final stage are normally only observable in the long-term, and as part of the general human influence, rather than being easily isolated in the short term.

This framework focuses mainly on the flow of movement from left to right, but the inclusion of the feedback loops shows that there are in reality flows of different types in both directions. There are significant impacts that the natural environment can have on society and universities, including destructive ones, and impacts of society and its different actors on the university. While the figure acknowledges these potential effects (ones that make necessary the adaptation pathways) the main focus in this paper is on the impacts of higher education on climate.

Mitigation and adaptation pathways

The following are the possible trajectories in practice of influence of the university on climate change, as indicated on Figure 3. A total of 15 pathways are outlined below, 10 of mitigation (labelled with M) and five of adaptation (labelled with A). These do not quite represent an exhaustive list – there are other conceivable routes – but they do constitute the most important and most commonly observed ones.

Figure 3: Mitigation and adaptation pathways



The key in Table 1 provides additional explanation of the pathway and the actions and impacts occurring at each stage:

Table 1: Pathways key

MITIGATION PATHWAYS

M1	Student acquires professional knowledge relating to climate change at university; applies that knowledge in the workplace and has an influence on others; impact on societal causes of climate change; impact on climate change mitigation.
M2	Student engages in broad learning, and personal and civic development, while at university; influences their own thought and action in later life; impact on climate change mitigation.
M3	Research is carried out on the climate; enhances societal understanding of the changes underway, their causes and possible responses; impact on climate change mitigation.
M4	University develops new products or technology for addressing climate change; taken up by government or business or civil society organisation; impact on climate change mitigation.
M5	University provides a service directly to an institution; institution develops policy; policy influences actions and behaviours; impact on climate change mitigation.
M6	University provides a service directly to a community; community enacts environmentally friendly measures; impact on climate change mitigation.
M7	University provides directly environmental service; impact on climate change mitigation.
M8	University engages in advocacy, campaigning or mobilisation; influence on government policy; policy influences societal actions and behaviours; impact on climate change mitigation.
M9	University engages directly with public in relation to climate change; change of understanding of climate change occurs, leading to some change of consumer and corporate behaviour; impact on climate change mitigation.
M10	University alters its own institutional functionings; impact on climate change mitigation.

ADAPTATION PATHWAYS

A1	University develops knowledge, skills and values in students; graduates have enhanced ability to adapt their lives to changing climate; knock-on impacts on broader society.
A2	University develops new products or technology for adaptation; adopted by population to address impacts of climate change.
A3	University provides advisory services to company; company adapts its operations in light of climate change.
A4	University provides service to communities; communities enhance their ability to adapt to changing climate.
A5	University adapts its own functioning to the changes brought by climate change.

STAGES

University

Society

Bridging Actors

Ecosphere

As is evident on the figure, all of the pathways start with one of the five modalities, but do not follow a uniform course, and do not necessarily manifest at each of the four stages. In the first instance, this is because adaptation measures do not aim to bring an impact on the ecosphere, so they do not ‘reach’ the final stage. And secondly, for mitigation measures, some of these occur within the university, some in specific individuals, communities or institutions, some require widespread societal uptake. In some cases the influence goes directly from university to ecosphere – for example, in the case of pollution emitted by university buildings. Initiatives relating to mitigation by definition involve the impact continuing all the way through to the ecosphere.

There are a larger number of pathways relating to mitigation, not because of its greater importance, but because of the complexity of its trajectories. While the pathways are identified as being either mitigation or adaptation, it might be possible for actions taken to constitute both at the same time. In practice, many actions to

adapt to climate change may also be mitigating it – for example, tree planting can reduce risk of flooding and also reduce levels of carbon dioxide in the atmosphere – but the pathways are kept separate here for analytical purposes. Curricular interventions will very often deal with both of these questions simultaneously, and buildings can be designed both to be more resilient to extreme weather and to be more efficient with energy.

Some examples of impacts for each of the pathways are outlined in Table 2:

Table 2: Positive impacts of universities on climate change

Pathway	**Area of activity**	**Example**
M1	Professional development	An engineer applying principles of sustainability in her building designs
M2	Personal transformation	Graduate has acquired basic knowledge of impact of greenhouse gases on the climate, and makes moves towards use of renewable energy sources in his own house and transport
M3	Research and scholarship	Paleoclimatological reconstruction of temperature rises over the past 1000 years, enabling understanding of the extent to which global warming is anthropogenic
M4	Application of knowledge / innovation	Geo-engineering technology developed for blocking the sun's rays
M5	Secondment	Environmental scientist is seconded to a government department to lead strategy on climate change
M6	Community engagement	University works with a housing association to make their energy usage more efficient and reduce fossil fuel emissions
M7	Environmental service	Students organise large-scale reforestation programme in areas surrounding the university
M8	Campaigning and mobilisation	University lecturers write open letter denouncing government subsidies to fossil fuel companies
M9	Awareness raising	University lecturer runs television series discussing how individuals can change their lifestyles to be more environmentally friendly
M10	Campus sustainability	Divestment of university endowment from shares in fossil fuel companies

A1	Personal transformation	Graduates have access to latest research and advice around flood risks, and adapt family homes accordingly.
A2	Research and scholarship	Researchers develop new technology for reducing soil salinity in coastal areas affected by rising sea levels
A3	Application of knowledge / innovation	Research findings allow a business to identify site for relocation to avoid rising seas levels
A4	Community engagement	University provides training course for local farmers in developing new crops that are appropriate for changing weather conditions
A5	Campus sustainability	Relocation of university building to avoid site vulnerable to mudslides in heavy rains

The pathways outlined above, and examples accompanying them, assume for these influences to be positive. However, it must be acknowledged that in all of these cases negative influences are possible, and do actually occur in a number of cases. Universities emit greenhouse gases directly through their own campuses, through the travel undertaken by their students and staff, and in some cases through their investments in fossil fuel corporations (Grady-Benson & Sarathy 2016). Public engagement can have a negative impact in cases in which professional scientists, or those with scientific training working for lobbying organisations or partisan think tanks, act deliberately to obscure public understanding of science or to propagate mistruths – as detailed in relation to the tobacco industry and global warming in the book and documentary *Merchants of Doubt* (Oreskes & Conway 2010).

Some potential negative impacts for each of the mitigation[3] pathways are outlined below:

Table 3: Negative impacts of universities on climate change

Pathway	Example
M1	Students develop professional competencies that allow them to increase fossil fuel extraction
M2	Students acquire attitudes privileging maximisation of profit over protection of natural environment
M3	Scientists funded by fossil fuel companies produce research that casts doubt on existing climate science and undermines existing efforts at reducing carbon usage
M4	University develops new products and technologies that are dependent on fossil fuel usage
M5	Lecturers seconded to think tanks work to undermine environmentalist agenda
M6	Community engagement project encourages a local community income-generation scheme that causes local environmental destruction
M7	Students cut down on area of old-growth forest as part of a cash crop scheme
M8	Anti-environmentalist public intellectuals provide academic backing for regressive policies of populist government
M9	Climate denial book written by university lecturer encourages scepticism amongst public
M10	Universities develop new student accommodation buildings without environmentally friendly specifications

In some cases, therefore, universities need to develop new lines of work which can have a positive impact on climate change; in many cases, however, it is a question of turning around existing negative influence or neutral influence, into positive influence. For example, university-based engineers may continue to contribute to infrastructure development, but utilising net zero technologies. The notion of embodiment, therefore, becomes relevant here. One of the ways this framework can be used is to allow universities to assess the alignment of the work they are doing in these different areas with their overarching aims – to determine whether a mission to support the SDGs, for example, is being supported in all the different aspects of the

[3] For the adaptation pathways, what is observable for the most part is lack of positive impact rather than actively negative impact.

work undertaken by the institution, or whether there are positive and negative influences running through different pathways.

Characteristics of the model

The relationship between higher education and climate change shows many of the characteristics of complex systems, as outlined by Tikly (2019). Complexity is a characteristic of the climate system generally, of the higher education system, and of the interaction between the two. As discussed above, the system has multiple positive and negative feedback loops, and being an open system, what happens inside and outside the university constantly modify one another. There are some elements of *autopoiesis* here, although it is not necessarily a self-regulating system in the sense of maintaining equilibrium, and there are many instances of instability.

Importantly, the system has the quality of 'emergence' – new action or being that evolves from the interaction between the elements, and that is not present in the original components. This quality is particularly crucial given the nature of the university as an institution focused on open-ended enquiry and the quest for human understanding (Collini 2012). Education and knowledge production have particular characteristics in that they involve reflection, enquiry and creation of ideas, and as such can modify their own nature in the course of the process. To give an example, a student may start out with an intention to pursue a course in business studies so as to become a successful entrepreneur, but through the processes of reflection engaged in during the course decides to abandon this life course and become a Greenpeace activist.

At first sight the figure may give the impression of being a closed system, but only because it cannot represent all of the external factors that can influence the processes. Crucial amongst these are dynamics of political economy that support or constrain change, constituting the 'conditions of possibility' discussed by Unterhalter et al. (2017). Clearly, the work of the university does not emerge from nothing, and a complete understanding of the dynamics involved would include the constitution of the different modalities – why do education, knowledge production and so forth

appear in the way they do? These are highly complex questions and involve a combination of immediate and direct factors, such as higher education policies and resourcing for the sector, and the preparation provided for students at lower levels of the education system, as well as deeper historical factors such as models of university and epistemic traditions. The purpose of this analysis is not to provide an account of the roots of university practice, so this part of the figure has been left implicit. Nevertheless, through the feedback loops coming back from community, society and ecosphere, it acknowledges that there are extensive impacts back on the universities themselves. Furthermore, the arrow to the left of the university column (Figure 2) shows the interrelationships between the modalities and the influences that they have on each other.

Like all representations of human systems and dynamics, the neat separations between different stages and actors are something of a fiction: for example, people who are in the ‘graduates’ box are simultaneously community members and work for governments, businesses and NGOs. Graduates act as agents of knock-on impact on others in society (for example, through their work as lawyers or computer engineers), but are also influenced by the work of other graduates in turn, and directly by the actions of the university. So the same people can be in the ‘bridging actor’ stage as in the ‘society’ stage, but fulfilling a different role in each case. Nevertheless, it is useful to separate out these categories in order to understand how these people mediate the influences of universities in different ways depending on the roles they are playing.

This diagram of course does not attempt to portray the entirety of the learning system – formal, non-formal and informal – and all the processes of knowledge production in a society – which would barely be possible in a single representation. The attempt here is only to look at how universities interact with climate change. In addition, the figure cannot capture all of the purposes and actions of universities, and their interactions with different spheres of society, but focuses only on those of relevance to climate change. Even in relation to the latter, the interactions are more extensive than those represented through the pathways. For example, community

members are involved in knowledge production through participating in focus groups, clinical trials and so forth.

In McCowan (2018), six dimensions of impact were identified: source, form, trajectory, intensity, timescale and destination. Of these, source, trajectory and destination are represented on the figure, indicating the ‘origin’ of the impact (say, a research project), its ‘trajectory’ (uptake of a new development by a solar panel company) and ‘destination’ (public administration buildings seeking to go carbon neutral). The usual caveats are necessary here around isolating causes and effects: these impacts do not originate purely in the university, they do not move on an entirely linear course, and may have diverse destinations of impact – so the pathways charted are approximations rather than absolute categories.

However, we also need to take into account the other three dimensions of impact: form, intensity and timescale. As regards form, the flows along the arrows in the diagram involve ideas and actors. While the two cannot exist separately, there is some distinctiveness of each: an output of the university might be a research paper – let’s take for example Mann et al.’s (1998) seminal article on changes in climate that led to the popularisation of the ‘hockey stick’ graph. The article is of course created by human beings, and is subsequently used by them, but the output itself is not in the form of a person, and is not confined to a particular person or set of people in its subsequent trajectory. In observing the impact of universities through ideas, we can distinguish between economic, political and cultural spheres – which, while all having a knock-on effect on climate change, will do so in different ways.

On the other hand, the output of the university might be in the form of persons, say a graduate in marine biology, who then goes on to work in the field of conservation of ocean life, and make a positive impact in that area. The graduate has acquired ideas within the university, and is employing them in her work, but it is not a specific idea or set of ideas that is making the impact, but the human being who combines them in particular ways in response to a specific set of external circumstances and problems to solve. In addition to ideas and actors, some outputs of the university are material

products, for example more affordable solar panels or a new form of combustion engine, which is subsequently used in aeroplanes to lower emissions.

The intensity of these different forms of impact varies greatly, depending on the ‘force’ of the original intervention by the university, and the resources deployed to maximise its impact subsequently. There are also variations of intensity depending on the stages through which the pathway passes, and the breadth of its reach – having potentially a strong impact on a small group of people, or a more diffuse influence on a large group, or on humanity as a whole. Universities emit carbon dioxide, which has a direct impact on the atmospheric conditions affecting the climate, yet it the emission constitutes a small proportion of all the carbon dioxide in the air. On the other hand, the education provided by universities may have a profound impact on the life of an individual, enabling further knock-on effects – perhaps enabling her to obtain a job in a local council, through which she is involved in establishing stricter regulatory code to reduce the number of high polluting vehicles. Any single action by a university of course will have a very small impact on temperature rises, though taken together, the effects may be substantial.

Lastly, there is timescale. There is a time lapse between the different stages – between those actors who come into direct contact with the university, the broader society, and then onto the ecosphere. In the framework put forward by Findler et al. (2019a), there are two stages of impact, direct and indirect – the former evident in the short term (for example uptake of research by a corporation), and the latter in the longer term (changing business practices). Direct and indirect impacts are indicated on the framework presented here, but should not necessarily be identified with the different stages of ‘bridging actors’ (direct) and ‘society’ (indirect): in some cases there may be direct impacts on society as a whole (development of new electric car technology), and even some direct impacts on the ecosphere (reduction in greenhouse gas emissions). Direct/indirect should also be distinguished from short/long term, although they may often coincide.

Nevertheless, there are significant differences of timing in the different forms of impact, which must be borne in mind given the urgent and time bound nature of

climate change itself, as well as the pressures on universities to show immediate tangible results of their work to justify their funding. The timescale element may interact with the other dimensions of intensity and form: the type of impact in question may change over time, or it might vary in its strength, either building up with time or dissipating.

A final point is that none of the pathways represented on the figure are inevitable, and it must be acknowledged that there is a degree of unpredictability in all of the trajectories of impact. In the first instance, human agency ensures that the processes and outcomes of teaching and research are inherently unpredictable: while a lecturer may have a particular learning outcome in mind, and a researcher a question to be answered, the process of pedagogical interaction or enquiry may end up leading to quite a different end point. And second, the complexity of the climate system ensures that even well-thought-out intentions may have unexpected environmental consequences. This element of uncertainty does not require us to abandon all modelling of the processes, but to let go of any rigidity in our application to actual contexts.

Conclusion

The framework outlined in this paper is both analytical and normative. In an analytical sense, it sheds light on what the university is doing, on the diverse pathways through which it impacts the society outside, and the likely effects on climate change. It puts forward a frame that highlights firstly the trajectory of impact (moving from one of the five modalities of the university to various bridging actors, to societies and to the ecosphere), and identifies form, intensity and timescale as key dimensions to be observed. It can serve, therefore, as a tool for researchers in locating the focus of their existing research onto the broader map of university action, and also in drawing attention to new elements of the processes.

Taking a broader view of the literature as a whole, the framework can reveal the emphases and also the silences and gaps. There is a general lack of research on

impact of universities on sustainable development, and of the studies that do exist, most have focused on just some of these pathways (M1, M2 and M10) – those relating to changes in the curriculum, and campus sustainability. There has been less attention to the knowledge production, public debate and service delivery activities of the university, and as a result we have only a partial understanding of the role of universities globally in these areas.

From a normative perspective, universities can utilise this framework to ensure that action is being taken across the diverse spheres of activity of the institution, and to assess the extent to which potential synergies are being exploited. There has been a welcome increase in attention to the environmental impact of university buildings, procurement and energy usage, along with efforts to measure and audit progress in these areas (Findler et al. 2019b; Vaughter et al. 2013). Yet the efforts of universities in other areas have been more limited (Henderson et al. 2017). While there has been an increase in taught courses related to climate change, and some integration into natural sciences and engineering, the topic is only sporadically covered in other disciplinary areas (Vaughter et al. 2013). There is extensive research on the climate itself, but much more work is needed in social sciences, arts and humanities to capture the deep societal roots of the question. Work in the areas of service delivery, public awareness and outreach (Hansen & Lehmann 2006) can be expanded significantly. Finally, a perennial challenge for universities is in ensuring that interactions between the modalities are maximised, synergies exploited – most obviously between teaching and research, but community engagement work and the campus too – and conflicts avoided. An ever-present contradiction, for example, is between the sustainability principles espoused by universities and their internationalisation strategies – usually involving extensive travel of students and staff with corresponding carbon emissions.

There has been growing attention over recent years to the SDGs in higher education, particularly amongst research intensive universities with a public good mission (such as Arizona State University, University of Manchester and University of British Columbia). Some of the new initiatives have involved mapping of existing work onto the SDGs, and reporting of impact – for example in the *Times Higher Education* impact ranking. In some cases, universities have gone beyond mapping to actively align their

work with the SDGs in an integrated fashion, as shown in the ‘living labs’ discussed in Purcell et al. (2019). Yet higher education is still a long way from implementing what Wals and Blewitt (2010) call the ‘third wave’ sustainability, “shifting from one of campus greening and curriculum integration to one of innovation and systemic change across the whole university” (p.70) and “the creation of space for transformative learning”. None of the studies reviewed in the Findler et al. (2019a) systematic review of the impact of higher education on sustainable development assessed a whole institution approach, as advocated by the United Nations Decade of Education for Sustainable Development.

The roots of climate change are human, and that means we need a human solution – one that involves changes in human understanding and action. In turn, this involves an engagement of the university which covers all of these diverse areas of action: here understood as the five modalities of education, production of knowledge, service delivery, public debate and campus operations. Furthermore, climate change needs to be addressed in all of the disciplinary areas, from natural sciences to social sciences and arts and humanities, in academic and professional courses. And in terms of research, in all areas of human enquiry. Furthermore, universities need to be working simultaneously at all stages (see Figure 2) – to bring changes in graduates, organisations and communities, in the broader political, economic and cultural sphere, and acting directly on the ecosphere.

The complexity of climate change is one of the reasons for the pre-eminent importance of the university in addressing it. It requires deep and sustained engagement in both empirical and theoretical realms, the painstaking collection of data on climate and human activity, and critical reflection on the connections and future ramifications. The ‘wicked’ elements of climate change will also require new approaches that break us out of traditional disciplinary moulds, ones that combine them or transcend them. It will certainly require the contributions of researchers in many parts of the world, working within different languages and cultures, and possibly with radically different epistemologies and ontologies.

Contestation raises highly complex epistemic issues that cannot be covered in full within this paper. Science through history has only progressed through questioning, critique and scepticism, and closing down the debate over climate change will be counter-productive. Equally, the distortions to the scientific debate brought through fossil fuel industry-funded think tanks purporting to act in the name of science have severely impeded understanding and action in the general population. Universities therefore have a crucial role in contributing to public debate, both in disseminating the scientific 'facts' about climate, but also in provoking reflection on the deep economic and political shifts required to address it.

Climate change is an unavoidably political question, and requires universities to engage closely with different stakeholders in society, and overcome any temptation towards introversion. Yet at the same time, the university requires some degree of 'insulation' from the day-to-day demands of society in order to generate new insights and breakthroughs. There needs to be a semipermeable membrane between university and society that allows movement of ideas and actors, but at the same time some degree of insulation to allow the deep reflection, and some cases laboratory conditions (either literally or metaphorically) for deep thought and experimentation to occur. It is important to emphasise – as argued in McCowan (2019) and elsewhere – that the university is an institution oriented towards critical reflection first and foremost, and not a machine for developing specific and predefined forms of impact. It may, and indeed is very likely to, produce those forms of impact, but the starting and ending point of the university – in Collini's (2012) words – is the pursuit of human understanding through open-ended enquiry.

Clearly, these actions taking place within the university do not occur in a vacuum. As argued by Robinson Pant (2020), the danger with systems thinking in education is to understand them as closed systems – the diagram outlined above is subject to constant influences from the society outside, and also generates its own emergent dynamics. The actions within each of the university modalities are made possible by political, economic and cultural forces acting on the university, and are more immediately conditioned by prevailing higher education policies, at the current time dominated by a combination of marketisation, status competition through national and

international rankings, and an incipient process of unbundling (Marginson 2011; McCowan 2019). Higher education is also locked in a perennial tension between production of private goods, ones which are disproportionately co-opted by privileged groups, and the production of public goods that can benefit all in society.

But the importance of the actions of the university does not reside only in its ability to bring change outside of itself. While this paper has focused on frameworks of impact, the *projective* role of the university must be accompanied by the *expressive*. The *embodiment* of the mission that the university espouses – in this case to combat the potentially catastrophic impact of climate change on humanity – involves the expression of the core values underpinning it within its own practices: from the more concrete actions of building sustainable campuses, to the construction of a cooperative interpersonal space and the fostering of an inclusive and dialogical epistemic environment. If the university achieves this, it will not necessarily have solved the conundrum of climate change – it cannot do this alone – but it will have wholeheartedly turned its creative force towards the unravelling of what is certainly the greatest and most intricate challenge facing humankind.

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