Globally-linked local innovation for sustainable development: implications for a new hybrid politics post-Rio+20

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This is an abridged version of a paper covering related ideas, to be published in 2014 in Environment & Planning C

Abstract

The ability of innovation – both technical and social - to stretch and redefine 'limits to growth' was recognised at Stockholm in 1972, and has been a key feature in debates and was centre-stage at Rio+20. Compared with previous major moments of global reflection about human and planetary futures – Stockholm, Rio in 1992, Johannesburg in 2002 – we now know much more about the dynamics of interacting social, technological and ecological systems and the ways these relate to other pressing imperatives at different levels. . At the same time, information and communication technologies are now offering new ways to link innovation for sustainability in different localities across the world. This paper asks what these changing conditions and insights offer in terms of governance approaches that might enhance the interaction between local initiatives and global sustainability objectives post-Rio+20?

The global political agenda over the last two decades has largely focussed on creating economic and regulatory incentives to drive more sustainable industrial development patterns within and between nation states – resulting most notably in the CBD and the UNFCCC. At the other end of the spectrum, 'Local Agenda 21', launched at the first Rio summit, envisaged a community-led response to sustainable development challenges. Local initiatives often flourished and drew on people's own, vibrant forms of knowledge, technology and experimentation, but for the most part they remained at the margins, focused on local sustainable development needs rather than articulating with bigger-picture global challenges. This paper discusses the successes and challenges of globally-linked local action through a number of illustrative examples, reflecting on how these have contributed to Rio 1992's original objectives. In doing so, we will draw upon innovation studies and development studies to highlight three key issues in a hybrid politics of innovation for sustainability that is required to link global and local. First, we highlight the direction in which innovation and development proceed. Second, the distribution of the costs, benefits and risks associated with such changes. Third, the diversity of approaches and forms of innovation that contribute to global transitions to sustainability. Drawing on this analysis, we will also reflect on Rio+20, including the extent to which hybrid innovation politics is already emerging, whether this was reflected in the formal Rio+20 outcomes, and what this suggests for the future of international sustainable development summits.

Introduction

International negotiations have long-sought new models of innovation for sustainable development. While the political leaders at the first 'earth summit' in Stockholm (1972) focussed much discussion on research agendas and technological breakthroughs that would reform industrialism, a group of activists set up an exhibition outside the main conference, where they displayed technologies which they saw as underpinning radical shifts to post-industrial, ecological societies organised at the local level (see for example, Harper and Boyle, 1976, Part B). Some of the technologies on display, such as wind turbines, are now established as multi-billion dollar global industries in a so-called "green economy". But at the time, these were positioned as alternatives to the high-tech incumbent approaches to energy generation that were dominated by state-supported industries and multi-national corporations.

As STEPS Centre researchers, we participated in a variety of Rio+20 events and activities before, during and after the Summit, and witnessed the persistence of these dichotomies between incumbent and alternative innovation for sustainability, at least rhetorically. In this paper we reflect on our participation in those debates, and our own research, in order to suggest that the dichotomy actually masks a more complex picture populated by diverse, hybrid forms of innovation for sustainability that can serve to link local and global changes.

Rather than counterposing what have become termed 'industrial' and 'grassroots' innovation approaches, we are increasingly witnessing the emergence of dynamic, hybrid combinations of both – shaped and facilitated by emergent private-public-NGO partnerships and new communications technologies. At Rio+20, these hybrid approaches were highly visible in the side events at Rio Centro and at the discussions at the *Cúpola dos Povos* (people's summit) in Flamengo, where diverse political groups focussed their attention not only on supporting or opposing specific technological solutions, but on a local-global transition to more sustainable development pathways.

Do these hybrid innovations bring with them a new politics? Or do they recast old political cleavages in new forms? To what extent did Rio+20 provide a forum for these politics to play out?

In this paper we make an initial attempt to map out the settings for these innovation politics, and provide heuristics that can help us to navigate them, drawing on a range of illustrative examples. We argue that the emerging politics of innovation – insufficiently addressed in the formal negotiations at Rio+20 - should be guided by a local-global agenda around the **directions** of innovation, the more equitable **distribution** of its costs, benefits and risks, and an appreciation of the **diversity** of innovation both across countries and within them. This '3D' agenda, we argue, sets the foundation for the kind of democratisation of science, technology and innovation that can enable creative local responses to flourish, whilst providing a guide for systemic shifts towards sustainable development at the global level.

Rio+20 and Innovation for Sustainable Development

The history of environmental summits can be viewed in terms of the contested politics of science, technology and innovation (STI) for more sustainable development. At each of the major gatherings – Stockholm 1972, Rio 1992, Johannesburg 2002 and Rio 2012, the role of technological change in stretching and redefining the ecological limits of a finite planet has been subject to vastly divergent views (for an early example see Cole *et al.*, 1973).

The outcome document from Rio+20 'The Future we Want' contains ten instances of the word "innovation", but is overwhelmingly focussed on the role of finance and the provision of advanced technologies from richer countries to the developing world ("technology transfer, as mutually agreed") and the need to "close the technological gap between developing and developed countries" (UNGA, 2012, para 48). The idea that innovation and solutions could emerge from the margins – for example from communities within developing countries - is almost absent, save only for two brief examples where the text recognises the 'grassroots' component to innovation.[1]

Prominent in the run-up to Rio, and informing the view of innovation as a market-driven process in the 'advanced' global North, was the narrative of the 'green economy'. UNEP describes the 'green economy' as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. In other words, we can think of a green economy as an economic environment that achieves low carbon emissions, resource efficiency and at the same time is socially inclusive" (UNEP, 2012). Part of this vision includes the internalisation of environmental costs into mainstream economic logics, which can act as a driver for innovation for sustainability. In response to this vision, some activists argued prior to Rio+20 that the Green Economy narrative (especially with respect to its potential for further commoditisation of aspects of the natural world like genetic resources and ecosystem functions, transforming them into 'natural capital') lost sight of the social justice dimensions of sustainable development (ETC Group, 2011).

To what extent did these debates echo the political lines drawn at earlier summits? We have tried to provide a partial summary to this question in Table 1.

The Stockholm Action Plan (UN Conference on the Human Environment, 1972, Part B) framed the role of technology at the international level around the UN assisting developing countries to access advanced technologies with respect to monitoring devices (like satellites for forestry), food technologies, appropriate technologies for water resource management, preventing mining hazards, and new energy technologies. NGO and civil society groups

[1] With respect to biodiversity, paragraph 197 states "We recognize that the traditional knowledge, innovations and practices of indigenous peoples and local communities make an important contribution to the conservation and sustainable use of biodiversity, and their wider application can support social well-being and sustainable livelihoods." This paragraph is rare in its recognition that innovation is not solely the domain of 'developed countries,' – a sentiment reinforced in paragraph 268 which stresses the need to "facilitate entrepreneurship and innovation including among women, the poor and the vulnerable.". Aside from these two instances, the recognition of knowledge and innovation in communities around the world is hardly visible at all.

(according to Dodds *et al.*, 2012, over 400 inter-governmental and non-governmental organizations were also present took part the process in a semi-detached arena, known as the Environment Forum (or, informally, the Hog Farm), at which the 1972 People's Summit (Björk, 2012), and co-ordination by activists and academics from across the world (Nilsson, 2003) provided radical alternatives.

An undercurrent of radical alternatives and bottom-up political initiatives was also visible at Rio 1992. Stakeholders at the Global Forum facilitated by the Centre for Our Common Future were estimated in the range 35,000 to 50,000 (Dodds *et al.*, 2012). In Rio, the geographical divide between the formal negotiations (in Riocentro 40km out of town), and the NGO-civil society discussions at the Global Forum (in Flamengo Park) was more notable than at Stockholm, as was the divided political flavour of discussions. The documents emerging from Rio 1992 retained a similar focus on global technological solutions to Stockholm, but also moved towards a greater recognition of the local (see also Lawhon and Patel, 2013). Whilst the Rio principles and the primary components of Agenda 21 – the action plan for sustainable development – kept the focus on transfer of modern technology from North to South, the recognition of community-led action through Local Agenda 21 also brought more attention to the potential for grassroots innovation. Principle 9 emerging from the Rio 1992 conference emphasised co-operation for sustainable development "by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies" (UNCED, 1992). At the same time, NGOs were brought in as partners in the sustainable development process and Agenda 21 was developed for implementation not just at the global level but also "nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment" (United Nations, 1992). Section 4, Chapter 34 stresses that tapping the pool of proprietary knowledge "and recombining it with local innovations to generate alternative technologies should be pursued" (United Nations, 1992).

The Johannesburg World Summit on Sustainable Development, notable for its focus on industry-led approaches to sustainable development, nevertheless took some of these ideas forward. For example in the energy sector: section II, part 20(g) called on governments to "develop and utilize indigenous energy sources and infrastructures for various local uses and promote rural community participation, including local Agenda 21 groups, with the support of the international community, in developing and utilizing renewable energy technologies to meet their daily energy needs to find simple and local solutions" (WSSD, 2002b).

The formal framing of technologically-advanced knowledge and expensive hardware being transferred (primarily from North to South) has therefore remained dominant throughout successive conferences. However civil society has often advocated radically different innovation processes – both those for the creation of technologies and for the transitions of socio-technical and ecological systems that they might enable (Smith, 2012). These alternative approaches – often no less knowledge intensive, but linked to more locally-derived, 'bottom-up' efforts to transform systems of production and consumption - can be characterised and compared to technology transfer approaches by identifying a number of dichotomies.

Name of conference	Global - Green industrialisation	Local - Grassroots innovation
United Nations Conference on the Human Environment Stockholm 1972	The conference delivered Principle 18. "Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind."	Environment Forum/ Hog Farm/ People's Summit – activists and academics co-ordinate to discuss radical, community-based alternatives to unsustainable industrial development paths (Björk, 2012; Nilsson, 2003).
United Nations Conference on Environment and Development - Rio 1992	'Business Charter for Sustainable Development' (International Chamber of Commerce) and 'Business Council for Sustainable Development' (BCSD), formed to give advice to UNCED from a business perspective… led to the formation of the World Business Council on Sustainable Development.	Global Forum in Flamengo Park – 35-50,000 participants discuss responses to challenges including climate change, biodiversity loss and marginalisation of indigenous peoples.
Johannesburg 2002	Increased emphasis on implementation, privatisation, PPPs and liberalisation as approaches to enhancing access (e.g. to water) and ensuring sustained natural resource management. First ICSU/ TWAS Forum on STI for Sustainable Development.	Amongst other activities, the People's Earth Summit spawned the Johannesburg Declaration on Biopiracy, Biodiversity and Community Right, recognising the key role played by local communities in the conservation and sustainable use of biodiversity (Biowatch 2002)
Rio+20	RioCentro debates focus on 'Green economy' and 'green growth' narratives, including new institutional mechanisms to incentivise eco-innovation and transfer of cleaner technologies – central role of (largely incumbent firms in) the private sector. ICSU Forum on Science, Technology and Innovation for Sustainable Development (PUC University Rio) precedes the conference.	Flamengo Park – alternative debates challenging those at RioCentro, organised by civil society groups (domestic and international), but with involvement and CSR support of Banco do Brasil and other private sector actors.

Table 1. Innovation for Sustainability at various UN sustainable development summits

Innovation for Sustainable Development: from dichotomies to hybrids

Through these historical debates, then, it is possible to discern two broad approaches to promoting science, technology and innovation (STI) in the stretching and redefining of environmental limits, and in dealing with ecological stress. In terms of the 'three pillars' of sustainable development, both of these seek more environmentally sustainable outcomes, but differ in their social and economic priorities, and in the forms of transition that they envisage. At the level of socio-techno-ecological systems at local and global levels, the protagonists of these approaches envisage different *pathways* (Leach et al., 2010) to sustainability and enact political strategies to try to ensure that they are realised.

Whilst these are not hard-and-fast distinctions, it is possible to identify two ends of a spectrum of innovation for sustainable development that focus on distinct actors, mechanisms, and knowledges. The first is led by large firms, or by public-private partnerships of multinationals and governments advocating a science-push, and top-down form of STI. Whilst the OECD and others argued for this approach at Stockholm, few governments and businesses really adopted it seriously until after Rio in 1992. It later attained greater influence through the public-private partnerships for implementing sustainable development at Johannesburg in 2002 (WSSD, 2002a), and later became influential in green economy arguments at the Rio+20 Summit. Driven by market values and business interests (e.g. 'cleantech venture capital'), with government support (e.g. through the clean development mechanism and, more recently, green stimulus packages). This approach – which we call *green industrialisation* - has traditionally emerged from innovation in the Global North, with diffusion and transfer to the South the most visible approach in formal intergovernmental negotiations and outcomes.

Green industrialisation approaches emerging in and around Rio+20 include the Global Green Growth Institute (3Gi), the World Bank's initiatives around its report on 'Inclusive Green Growth' (World Bank, 2012), the OECD's work on green growth and sustainable development, green growth in developing countries and consumption, innovation and the environment and the Green Growth Knowledge Platform (itself supported by the 3Gi, World Bank, UNEP and the OECD). 'Emblematic innovations' in green industrialisation might include nuclear power, carbon capture and storage, hydrogen fuel cells IP-driven transgenic crops and smart homes.

The second approach is rooted more centrally in civil society, and argues for a more participatory, bottom-up form of knowledge production and innovation for sustainability that responds to local situations and the interests and values of the communities involved. After Stockholm it found a focus in appropriate and alternative technology debates, and became associated with Local Agenda 21 after Rio in 1992 (Smith, 2005). This *grassroots innovation* approach for STI, driven by citizen action and emphasizing social justice concerns, was more prevalent in and around the People's Summit, beyond the inter-governmental negotiations at Rio+20.

In contrast to the green industrialisation approach, grassroots initiatives seek deeper, alternative forms of sustainable development – forwarding a more transformative agenda around the reorientation and transformation of socio-technical systems. These forms of

innovation emerge both in the global South (e.g. in rural development), and from community action in the North (e.g. community energy projects), and have in both contexts represented an alternative to the industrialisation approach (Gupta, 2009; Seyfang and Smith, 2007). 'Emblematic' grassroots innovations might include Micro-hydro, solar home systems, organic food, farmer-led seed production or vernacular housing.

The dichotomies discussed above echo discourse theories in environment-development politics, such as those offered by Tim O'Riordan (1976) (techno-fixes versus ecologists) or John Dryzek (1997); as well as in development studies and practice (industrial blueprints versus participatory processes; developmentalism versus post-development; market-led vs. social paradigms) (Rist, 2011). As discussed earlier, these two contrasting approaches to STI have been reflected in all summits, from Stockholm to Rio+20.

However, such stylised representations may in fact hide other forms of innovation. These two approaches are instead best understood as 'ends of the spectrum', within which a range of hybrid possibilities lie. As we discuss below, this traditional dichotomy is increasingly being supplemented by a space of diverse experimentation in hybrid forms of STI for sustainability between these poles. Nevertheless, conventional tensions between these approaches are creating a splintering and reconfiguring, making way for a new politics of innovation for sustainability.

Hybrid innovation for sustainable development

Hybrids operate across all dimensions (political, actors and mechanisms, knowledge). They include, for instance, grassroots innovation movements adapting high-tech devices and infrastructures (especially to share digitally-encoded ideas through open-source peer production networks, such as Hackerspaces) (Anderson, 2012), corporations innovating products for marginal consumers, to be distributed by poor employees to the 'bottom of the pyramid' (Prahalad, 2004), disparate communities of individuals working voluntarily across international borders towards shared global challenges or for political advocacy (Shirky, 2008), efforts to support the application of technologies in informal sector enterprises (Cozzens and Sutz, 2012), or to bring together networks and movements combining traditional knowledge and laboratory research to generate accessible and effective plant-based (pharmaceutical/ cosmetic/ food) products (Gupta, 2009).

Thus, transcending the dichotomies described above, we see innovation processes that involve actors from across both not-for-profit and private sectors (but primarily from outside government) in dynamic alliances and relationships that form outside traditional political arenas. Many hybrids embody uneasy combinations of values that can be described as 'not *just* for profit' and link both to business values but also co-operative motivations for green or social enterprise. They are financed by specialised venture capital, by microfinance or increasingly by crowd-sourced capital, and adopt an openness with respect to data and innovation processes that is absent in traditional 'green industrialisation' approaches. The hybrid innovations that we are increasingly witnessing are able to draw on multiple forms of knowledge and bridge across sites of formal R&D and more bottom-up, community-based ingenuity.

The examples below – purposefully chosen to give a historical perspective - illustrate this hybridity further by comparing oppositional approaches with networked, multi-level, transformative approaches in two sectors: agricultural (primarily seed) innovation and wind-based power generation.

Sustainable intensification and crowd-sourced agricultural strategies

Institutional infrastructures comprising networked national agricultural research systems and CGIAR Centres have led the development of 'industrial' agricultural technologies since the 1970s, drawing on breeding techniques and genetics research pioneered and applied in (especially US) seed firms. Alongside these international efforts, farmer-led agricultural development (Chambers et al 1989) offered an alternative to green revolution discourses and focussed on farmers' own local knowledge that was so often overlooked by professionals in the research system. This dichotomy has been visible ever since, especially in conflicts around the use of genetic technologies and resources (Scoones and Thompson 2011).

Whilst formal debates around agriculture and genetic resources at the Johannesburg 2002 summit focussed on access and benefit sharing under the Convention on Biological Diversity, conflicting visions over the applicability of various agricultural technologies (especially the use of transgenic crops) raged. The farmer participatory plant breeding movement was counter-posed as an alternative to various applications of genetic technologies (largely controlled by a small group of multinational corporations), and the International Agreement on Plant Genetic Resources for Food and Agriculture (otherwise known as the 'International Seed Treaty', which aimed to secure 'farmers' rights' to such resources) had been agreed the year before.

Johannesburg also took place less than one year before the USA, allied with other large grain exporting countries (among the third parties Australia, Argentina, Canada) launched WTO dispute DS291 on European 'Measures Affecting the Approval and Marketing of Biotech Products'. The role of agricultural biotechnologies in intensive, industrial agriculture was clearly delineated from the low external input sustainable agriculture favoured by a strong international network of civil society groups working on food security (and, later, food sovereignty) (Millstone and Van Zwanenberg, 2003).

More recently technological developments (including in bioinformatic technologies) enabling cisgenics and marker-assisted selection to bridge across to conventional or participatory breeding techniques, the potential for hybrids (in the sense of this paper, rather than hybrid seeds) is increasing. Whilst organisations such as Cambia have attempted to provide open-source (transgenic) models in this area, international legal frameworks are gradually overcoming the barriers for international collaborative work bridging local, situated and scientific forms of knowledge. The International Seed Treaty's attempts to ease the flow of genetic material internationally through its 'Easy-SMTA' (Standard Material Transfer Agreements) contributes to easier genetic exchange, and its global information system (http://www.planttreaty.org/content/gis) also helps by linking with the Convention on Biological Diversity's Clearing House Mechanism. The Nagoya

Protocol on Access and Benefit Sharing now provides a framework (although far from ready for implementation) for globally-networked, hybrid innovation approaches.

In this context, a number of hybrid innovation initiatives are emerging. For example, 'citizen scientists' have been drawing onmodern agricultural biotechnology and local farmer knowledge around seed saving and exchange, conserving diverse traditional varieties and experimenting with non-industrial supply channels (Stilgoe, 2009). Participatory plant breeding, involving alliances between farmers and scientists, has been shown to improve the quality and speed of plant breeding, as in India (Walker 2006; Witcombe et al 2011) or in France at INRA (The Institute for Agronomic Research) which has focussed on maintaining diversity in cauliflower seeds through work with NGOs like Réseau Semences Paysannes (the Peasants' Seeds Network).

Researchers have even pointed to the potential of combining open source approaches to knowledge sharing with modern biotechnologies for agricultural development (Adenle *et al.*, 2012). The considerable potentials of lab-based genomics with field-based farmer assessments have been highlighted as a way of radically changing the way plant breeding is practised, drawing on very different sources of knowledge (Offei et al, 2010; Richards et al, 2009). Others have pointed towards the potential of hybrid innovation approaches that combine bioinformatic and communications technologies with farmer participation, bridging high-tech and participatory approaches through crowdsourcing seed innovation. Such approaches, using mobile devices for information sourcing and open access software for data management for examples, offer hybrid approaches which could "not only be scalable, but also inclusive through the strengthening of crop diversity as an open informational resource" (Van Etten, 2011).

Hybrid wind energy formation

Wind energy is frequently referred to within the green industrialisation approach to STI. It is a relative market success in sustainable technology, with huge growth and investment led by utilities and institutional investment funds. It is interesting (for the purposes of this paper at least) that the origins of this successful industry rest in grassroots innovation approaches, specifically in Denmark.

Wind energy began its significant international expansion in the early 1990s.[2] The fact that Danish turbine designs in the late 1980s could generate 70 to 100 per cent more electricity than competitors, owing to a more robust and reliable design (Karnøe, 1996, p.773), meant the former were well-placed to lead in the new markets. By the turn of the century, the Danish wind energy industry was world leader, with a turnover of €3 billion, employing over 20,000 people, commanding 50 per cent of the world market.[3] Competition has intensified since then, but largely around the same turbine design as that pioneered by Danish manufacturers. Manufacturers in Germany and, more recently, India and China are taking increasing shares in regional markets (Lema and Lema, 2012). The expansion of wind energy has become an archetype for ecological modernization discourses and clean tech innovation policy.

[2] This section draws upon material in Smith (2006).

[3] Data supplied by the Danish Wind Industry Association.

Often overlooked are the roots of this development. Danish environmentalists, who like those elsewhere wanted alternatives to the nuclear power vision being pushed by states and some electricity utilities in the 1970s, were also unusually practical in reclaiming wind energy technologies overlooked since the 1940s. Turbine development can be traced back through an environmentalist milieu to a deeper culture of collaborative craft production and a tradition of co-operative organisation in Denmark that, in many respects, anticipated the open source movement. Social networks built up which shared knowledge, experience and ideas about turbine construction and use. The Organisation for Renewable Energy[4] held wind meetings, and disseminated test results and other information about different turbine designs and products through its monthly magazine *Naturilig Energi* (Natural Energy). A social innovation – a new form of community-based wind co-operative – facilitated investment in turbines for local use, and thereby helped create a market. Some local agricultural machinery manufacturers noticed this niche market, and, enterprisingly, began manufacturing wind turbines. In both cases, the designs drew on past, practical experience, and tended to be robustly made owing to the craft-based engineering skills and tools available.

The grassroots were also lobbying government to support their cause. The (pro-nuclear) electricity utilities needed to be persuaded into connecting community turbines to the electricity grid. Government support to this effect did eventually occur, as did the creation of a testing and research facility for the use of small turbine manufacturers at the government's Risø laboratory. This further helped develop practical experience with different design options, co-ordinate standards, and certify the viability of turbines. Support for the grassroots initiatives was by no means easily forthcoming, but what support there was seemed to work. Indeed, learning-by-doing had improved reliability and performance to such a degree that the government announced investment subsidies for turbine installations in the early 1980s. This made it easier for wind co-operatives to purchase and install grid-connected turbines for local electricity supply. Danish turbine manufacturers also performed relatively well in the Californian wind-rush of 1980 to 1986. The Danish wind energy industry began its international emergence.

As they emerged, grassroots approaches gained international attention. The people's summit at Rio 1992 focussed a great deal of attention on distributed wind energy, and such approaches were referred to for example in the Johannesburg Plan of Implementation, which called on governments to fulfil their common but differentiated responsibilities around energy, including "actions at all levels to: (g) Develop and utilize indigenous energy sources and infrastructures for various local uses and promote rural community participation, including local Agenda 21 groups, with the support of the international community, in developing and utilizing renewable energy technologies to meet their daily energy needs to find simple and local solutions" (WSSD, 2002b).

As mentioned above, wind energy is now a large, high-tech engineering industry. Co-operatively owned wind turbines pioneered in Denmark have been superseded by large

[4] It was created in 1975. Preben Maegaard, a 'grassroots engineer' played a part in its creation, as well as establishing the Northern Jutland Centre for Alternative Technology (Jamison, 2002, p.4).

utility- and investor-owned wind parks using giant turbines greater than 3MW (100 times more powerful than earlier 30kW turbines). This clean tech industry has come a long way from the back-yard idealists and grassroots innovators. And yet, this move from the grassroots towards one more akin to 'green industrialisation' is accompanied by other hybridisations. Community-owned energy projects are growing in popularity in some locations, such as 'citizens power' movements in the US and Europe. And grassroots innovators continue to experiment with small turbine designs for local, low power use, typically in remote rural locations; sometimes in response to diminishing smaller-scale turbine supply options arising from the dominance of big wind.

These examples from the agriculture and energy sectors – like other innovation approaches in different sectors - transcend the grassroots/ green industrialisation dichotomies above by being the product of both community level ingenuity and industrial technologies, being driven both by the profit motive (associated with varying levels of appropriation and different sources of investment) and social values, and by drawing on multiple forms of knowledge – both technical and non-technical – and recombining them to produce new ways of responding to sustainable development challenges.

At the same time, in many cases these approaches begin to bridge earlier 'global/local' (top-down/ bottom-up) divisions by being at once sensitive to local contexts but applicable – in altered and adapted forms – across diverse regions. The existence of these hybrid approaches at Rio+20 offered the promise that benefits previously seen only in localities could be translated to greater scales.

Scholars of grassroots innovation elsewhere (Smith et al., 2013), however, describe how these kinds of innovations need simultaneously to fit into existing socio-technical-ecological systems whilst in many cases simultaneously attempting to destabilise and transform them to create more sustainable systems of consumption and production. Translation from the local to global scales thus brings with it the hope (and threat) of wider transformational change as these innovations reconfigure social relations and create greener, more inclusive and socially-just economies. It is this potential for transitions and transformational change, amidst power relations often stacked against such alternative pathways (Smith, 2007), that brings with hybrid innovation approaches a new politics – one that is worthy of further discussion and analysis.

The 3D politics of hybrid innovation

The hybrid innovation approaches described above are more dynamic, complex and unpredictable than the green industrialisation approaches that national governments and intergovernmental negotiations have been used to dealing with. They also go beyond the grassroots approaches, linking to new sources of innovation and market players. They entail more varied and unstable relations between actors, mechanisms and knowledges than either green industrialisation or grassroots approaches imply, especially in an increasingly networked world. As a consequence, hybrid innovation approaches entail a novel politics, structured by new power relations.

These novel politics involve tensions between winners and losers, and relate to power and control over innovation pathways, processes and outcomes, which the diverse actors involved struggle to negotiate. Across hybrid alliances, not all participating organisations are equally endowed; each brings their resources to the partnership – profiting from interdependencies whilst attempting to secure continued access and control (Smith, 2006b). Tensions can arise as alliances and innovation processes shape current and future access to information, knowledge, technology, authority and finance, especially where developing infrastructures and formal agreements can harden asymmetrical relationships.

At the same time, beneath this recast innovation politics lurk some enduring fundamentals familiar to the older dichotomies. Specifically, a number of perennially contentious issues form sites of tension and negotiation within, and characterising, the new hybrid politics of innovation, as transformative pathways to sustainability are sought:

- *Appropriation* – many hybrid approaches adopt non-traditional models of intellectual property such as open source or forms of creative commons licensing. These are in many cases unfamiliar to those organisations from the 'green industrialisation' approach and some new models of appropriation may meet with resistance from the 'old guard'.

- *Commodification* – within emerging regulatory regimes attempting to place a monetary value on polluting emissions (e.g. CO_2), or potentially on biodiversity or ecosystem services, green enterprise is often seen as commodifying lifeworlds and nature itself (Fairhead et al 2012).

- *Risk governance* – with the forging of new innovation pathways come risks, uncertainties, ambiguities and ignorance (Stirling, 1998). Responsibility for the potentially negative impacts of innovation is negotiated alongside control and access to the benefits, raising significant challenges for globally-co-ordinated but locally implemented regulation (Van Zwanenberg et al., 2011).

- *Market and non-market mechanisms* – whilst traditional political responses to green industrialisation models relied on economic instruments and market mechanisms favouring incumbents or conventional business models, emerging hybrids often rely more on the role of (co-operative) networks and solidarity economies to disrupt incumbent economic arrangements and may therefore be incompatible with conventional policy goals.

- *Investment challenges* – again constrained by structural economic barriers, hybrid innovations – when they require external funding – struggle to access venture capital from traditional sources that hold particular expectations around returns, time-frames and size of investment and are wary of opportunity costs (when comparing more complex investments to more traditional 'green industrialisation' approaches). At the same time, when state support is called upon, vulnerability to capture by key incumbents and to economic cycles (as seen in Rio+20) can cause further political tensions (as can be argued has been the case with support for wind against a background of fossil fuel incumbency).

- *Diverse settings* - these politics are not played out in the familiar arenas of governmental/ intergovernmental conferences but through the processes of alliance-building and innovation itself. Actors can find it uncomfortable and difficult to operate beyond familiar sites, suggesting a need for professionals who are able to bridge across to more dynamic domains of corporate-civil society alliances, open-source movements and development groups working in diverse contexts around the world (Leach and Scoones 2006).

- *Distributed knowledge* - hybrid approaches must wrestle with both global scientifically determined notions of sustainability, and with other – more situated - understandings based on local cultural perspectives, priorities and epistemologies. Bridging such disparate epistemologies of sustainability – elsewhere termed 'sustainability brokering' (Leach et al., 2012) - is therefore key, but also a process entangled with sometimes-fraught politics of knowledge.

These tensions were evident in debates at Rio+20. Taking them seriously, we see that the new politics of (hybrid) innovation lies in the negotiation and settlement on which *pathways* of change emerge at different levels from local to national to international – where pathways refer to intertwined and mutually supportive social, technological, ecological, economic, institutional and knowledge processes (Leach et al 2010). Corporatist-managerialist approaches of business strategy, providing financial support and creating a regulatory framework that provides market signals to drive green industrialisation are therefore insufficient to enhance or even keep up with hybrid innovation approaches. As researchers from the STEPS Centre, we suggest a '3D' political agenda for innovation – around ***direction***, ***distribution*** and ***diversity*** – that can act as a heuristic in understanding some of the tensions above and for guiding innovation and its politics in these emerging hybrid areas.

Firstly, more attention is required to the orientation of the specific ***directions*** of social, technological and environmental change that hybrid innovations especially help engender. Beyond being clear on the particular goals and principles driving innovation (for example meeting specific MDGs whilst avoiding environmental stresses), this involves a recognition that multiple possible pathways are indeed available, but that particular courses of action – involving interacting social, technological and environmental processes - will be self-reinforcing, narrowing our options for future pathways. An attention to *directions* therefore requires a reflexivity towards these processes of *closing down* and an open, transparent politics to enable their full implications (and associated contestations and trade-offs) to be explored.

In recognising the potential for different directions of innovation, a second component of a 3D agenda is the associated ***distribution*** of costs, benefits and risks resulting from these potential pathways. Questions of distribution relate to who gains and who loses from particular policies and innovations, who controls them as they move forward (or, conversely, who is empowered by the process of innovation), and who bears responsibility for ensuring that the sustainability benefits of certain courses of action are not outweighed by negative effects on more marginal groups within society.

In trying to reconcile these different perspectives and trade-offs, the 3D agenda for hybrid innovation recognises the crucial importance of fostering ***diversity*** in any given field. This is so, equally in terms of maintaining a diversity of knowledges and ways of doing things that can contribute to sustainable development in the future; in terms of harnessing experimentation in diverse new innovation directions, and in terms of 'fitting' innovation to diverse places and contextsIt is in these terms that *diversity* (discussed in more detail by Stirling, 2007) allows us better to respond to ignorance arising from complex technological, environmental and socio-political dynamics, guards against lock-in to dominant (and sometimes unsustainable) pathways and provides a stronger foundation for future recombinations of knowledge and resources that fuel innovation.

We now turn to asking how and to what extent the Rio+20 conference dealt with the '3D' politics of hybrid innovation, and what role might future intergovernmental exercises play in facilitating and supporting hybrid innovation approaches into the future?

Rio+20 and the role of International Sustainable Development Summits

At Rio+20, as in Johannesburg, the UN adopted a convening role, trying to facilitate alliances between actors and – notably – moving far beyond the traditional intergovernmental frame to adopt a new organisational role as a partnership broker:

"The UN once dealt only with governments. But now we know that peace and prosperity cannot be achieved without partnerships involving governments, international organizations, the business community and civil society. In today's world, we depend on each other"

(Kofi Annan addressing the WEF 1999, quoted in Dodds *et al.*, 2012, page 231).

The Rio+20 negotiations retained a similarly structured and formal approach to previous summits (with the same geographical separation between Rio Centro and Flamengo as 20 years previously), but the side events at RioCentro were left more open, with more approved non-governmental organisations attending than ever before - allowing space for hybridization, plurality and the formation of rapid and dynamic partnerships and networks. This convening/ brokering role involved providing a repository for voluntary commitments from across governments, the private sector and civil society. $513 billion of voluntary commitments were recorded, such as "empowering 5000 women entrepreneurs in green economy businesses in Africa", and recycling 800,000 tonnes of PVC per year (UN News Centre, 2012). It was also illustrated by the conference's brokering hybrid interactions via a 'partnerships forum', session 4 of which was entitled "Speed-Brokering for Partnerships: Scaling Up and Replicating Best Practices in Sustainable Development" and focused on the themes of energy, sustainable cities, and water (United Nations, 2012).

Alongside this reinvigorated focus on partnerships, the UN had made efforts to involve the wider global community in the run-up to the conference and the Secretary General of Rio+20, Sha Zukang, claimed that 50 million people "took part" in the event via social media (UN News Centre, 2012). The 'Rio+20 Dialogues' (http://vote.riodialogues.org/) attempted

to bring wider civil society into the process through a networked, virtual approach to formulating recommendations. Rio+20 saw the emergence of a global citizens' movement for sustainable development – working together with the United Nations Department of Economic and Social Affairs but largely in the absence of inputs from individual nation states. The People's summit, including numerous parallel sessions (but no formal outcome document) drew together civil society and support from the private sector, transcending and blurring some of the differences between types of actor that divided the industrial and grassroots approaches and that had been prevalent in previous summits.

At the same time, however, the speed of these interactions and dynamic nature of the political connections being formed had two critical consequences. First, the UN - and indeed member states – struggled to keep up. Whereas one UN agenda and plan of implementation at Rio in 1992 and Johannesburg in 2002 may have seemed reasonable, Rio+20 revealed how impossible such a managerialist approach is in the current context, and reinforced the need for an ongoing, open politics of innovation for sustainability.

Second, there was little space to pause and reflect on just how inclusive and progressive the hybrid innovations being discussed actually were. The forms that dialogue took, and the character of the negotiation spaces and texts, often served more to quell and disable resistance to dominant political-economic and market agendas through the illusion of dialogue, rather than to encourage sharp debate about how to rebalance the power between different innovation pathways.

Efforts to incorporate these dynamic politics into the formal negotiations were – regrettably - absent. Many of the UN outcomes of Rio+20 (such as the establishment of the Rio+ Centre, the UNEP Sustainable Consumption and Production programme and the new incarnation of the UN Commission on Sustainable Development), point to means of sharing experiences, but without current plans for intervening politically. However the conflicts described above underline that attention to the politics of innovation processes is required if future negotiations and multilateral efforts are to succeed in enhancing more equitable hybrid innovations for sustainability. Rather than focussing around traditional faultlines and dichotomies, we propose that these politics attend instead to the directions of innovation, the distribution of the associated costs, benefits and risks and the diversity of innovation approaches that are enabled and supported in any given area.

This leads us to propose a new role for the UN and for future summits (or more networked, virtual alternatives). Alongside a brokering role for hybridisation, an ongoing requirement of international sustainable development summits will be to open up the space for different innovation approaches in ways that ensure the grassroots can participate fully and centrally in shaping the '3D' implications of any proposed outcomes and actions. This includes providing support for marginalised groups to craft new forms of grassroots innovation and green industrialisation (and therefore more democratic hybrids thereof). In our view, this policy and political commitment has to be pursued beyond the networks and arenas of global debate. At international, national and local levels, it needs to be pushed into the institutions of science and technology itself, such that the agendas of research institutes, technology strategies, investment portfolios and skills programmes that currently shape

dominant trajectories are opened up to democratic participation for developing pathways to sustainability.

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