Rethinking the science–policy interface in South Africa: Experiments in knowledge co-production

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This article contributes to the increasingly significant discussion about the science–policy interface. The challenge therein is that such a discussion tends to revolve around two seemingly mutually exclusive approaches: the reflexive approach inspired by Maarten Hajer's work that deconstructs the discourses of participatory policymaking, and the more normative transdisciplinary approaches that legitimise researchers as active change agents. With reference to a discussion of three South African case studies characterised by practical involvement of researchers in change processes, it is concluded that both approaches have merit and can improve the other: the reflexive approach could benefit from a better understanding of appropriate research methods for facilitating authentic engagement and participation, and the transdisciplinary approach could benefit from some reflexive caution about the change agent roles of researchers. The dynamics of the case studies and conclusions are significant in light of the fact that the South African research community is being influenced by re-alignments in the global scientific research community, resulting in an increasing emphasis on the need to do transdisciplinary research. For example, the adoption by some of the most significant global scientific associations in the natural and social sciences of the Future Earth platform at the Rio+20 conference in 2012 reflects most clearly this re-alignment. Researchers would be well advised to critically engage this agenda rather than presume it means little more than a rewording of traditional interdisciplinary approaches.

Introduction

The role of academic researchers in formulating policies about sustainability has drawn increasing interest from a wide range of different perspectives.[1] In this article, two particularly influential perspectives, which have in common a focus on the role of the researcher at the science–policy interface, are addressed. Inspired mainly by the work of the Dutch social scientist Maarten Hajer, one group is interested in a reflexive approach that reveals how researchers transform their craft into advocacy but rarely admit to their discursive role in complex power relations.[2-5] The second group works with theories of transdisciplinary research to develop a normative approach that intentionally promotes researchers as active 'co-producers' of problem-solving knowledge.[6,7] Perspectives that deal with the institutional dynamics of the science–policy interface[8] are not addressed.

While both traditions addressed here favour the active engagement of researchers in policy processes, they are concerned with very different dimensions. However, it will be argued that the reflexive approach could benefit from a greater appreciation of the practical methodologies and methods of co-production, while the transdisciplinary approach could be more reflexive about the consequences (and potential dangers) of combining researcher and advocacy roles. Considering the central place given to 'transdisciplinary research' in the new Future Earth programme adopted by the global science community at the so-called Rio+20 conference in 2012, it is an appropriate time to deliberate on these matters.

A synthesis of the reflexive and transdisciplinary approaches is used to reflect on three case studies from the South African context. These cases reveal the intricate dynamics of the science–policy interface where the search is on for ways of formulating sustainable solutions to South Africa's challenges.[8,9]

Reflexive approach

Since 1994 it has become common practice for South African scientists, academics and professional researchers to be drawn into the policy formation process as drafters of policy documents and background 'research papers'. Quite often the resulting policy is justified on the grounds that the policy formulation process was legitimate, because the inputs were not simply the 'subjective' perspectives of stakeholders and politicians but also 'objective' analyses of scientists and researchers. Fortunately, recent research[8] has started to raise questions about the validity of this 'required by science' discourse, and often draws on Maarten Hajer's influential work.[2-5]

Instead of accepting that participation of stakeholders and experts by definition improves policy content, Hajer deploys a constructivist approach to question what he calls the 'staged performances'[4] put on by policy managers who are obliged by their political and managerial masters to produce consensual outcomes. Usually this 'performance' means setting up processes in ways that reinforce consensus and suppress conflict.

Hajer's approach recognises the 'performative dimension of policy deliberation'. Like staging a dramatic production, the policy manager is effectively the orchestrator of a process that not only has a 'script', but also a physical 'setting' (e.g. venues organised in a certain way) within which a production is 'staged' (by a specific set of actors mandated to participate in the process), and a particular pattern of 'performances' (e.g. chaired/facilitated in a certain way, in a certain language) that are all equally important in shaping the final outcome as well as who can and cannot participate or whose voice carries more weight. To focus only on the script (i.e. the formal outcome of the process which is the text) is to miss the full significance of what is going on.

This application of theatre theory is what Hajer calls the 'dramaturgy' of the policy deliberation process.[3] It helps us to understand why formalistic participatory processes are often meaningless: stakeholders often just play out predetermined roles as defined by the script, setting and stage manager. It also helps us to understand how 'even with the same cast, policy deliberation can change face through experiments with new settings and stagings'[3].

Policy deliberation will not change just because there are skilled facilitators in place, or because there is improved capacity to be reflexive. It may have a better chance of happening if informed by particular methodologies and methods for co-producing knowledge. To achieve this enriched understanding of the policy deliberation process, it may help to apply the transdisciplinary research approach to give greater emphasis to a more reflexive practice at the science–policy interface.

Transdisciplinary approach

Transdisciplinary research has emerged as a mode of knowledge co-production that goes well beyond the traditional understanding of interdisciplinary research. The best way to define it is that it entails conducting interdisciplinary research with – rather than for – society in order to co-produce socially robust solutions to complex societal problems that can no longer be approached and solved by mono- or even interdisciplinary approaches.[6,7,10-14] Following Latour, this shift from 'for' to 'with' opens up a Pandora's box of old and new debates about the profoundly relational character of knowledge that can no longer be reduced to the quantitative enumerations regarded as sacrosanct by the natural sciences.[15]

Global warming, natural resource depletion and increasing poverty are just a few complex societal problems warranting a transdisciplinary response. They are complex because they are truly planetary-level problems, and because they are being produced by both nature and society and have long-term consequences for both. These 'hybrid' problems can no longer be approached by treating the 'natural' and the 'social' as two fundamentally different and unconnected realities which must, in turn, be worked on separately by the natural and social sciences in isolation of society. This divided approach can only result in producing partial knowledge of these problems, whereas the need today is clearly for integrated solutions based on integrated knowledge sets.[16]

To justify its claim as a new mode of knowledge co-production, it has been critical for researchers working from a transdisciplinary approach to establish the approach within the scientific community as credible and scientific. They have attempted to demonstrate that it is necessary to start with shared real-world problem statements which can then be translated into scientific problem statements and research questions. This outline then provides the basis for research that is co-produced with societal actors to produce knowledge that is relevant to societal actors and valid 'scientific knowledge'.

The transdisciplinary approach has very much been focused on the discovery, design and production of appropriate transdisciplinary methods that are replicable in different contexts. These methods are intended to successfully integrate quantitative and qualitative theoretical knowledge with socially generated transformative knowledge, to produce 'scientifically valid' and 'socially useful' knowledge. But in so doing, the transdisciplinary approach has – using Hajer's terms – not only produced a new script, but created the justification for a much bolder and comprehensive dramaturgy that the average researcher is now expected to manage. In practice, this creates for the researcher a more complex mode of double participation – as both 'participating insider' and as 'observing stranger'.

A reflexive note

Three cases from the South African context have been selected to highlight both the need for co-production of knowledge to address real-world problems and the need for critical reflexivity about the practices of engagement by researchers at the science–policy interface. They have been written up in ways that reveal how the use of words like 'objective' and 'subjective' are misleading because they imply that only experts can know the objective world 'out there' and that the subjective world 'in here' is not therefore relevant. Both 'worlds' interact as researchers position themselves within an inescapable paradox: embedded within the power relations of the contexture while at the same time entrusted as producer of analyses in accordance with the formal rules of science.

The first case is about formulating a 10-year policy framework for the national Department of Science and Technology which is a department mandated to invest in science and technology research. The second case refers to an ambitious urban regeneration strategy for Cape Town by the Western Cape Provincial Government (WCPG). Finally, the third case concerns the iShack project in the university town of Stellenbosch, aimed at addressing the challenge of incremental upgrading of informal settlements.

In all three cases I was involved as a researcher with specific knowledge expertise, but I was also an advocate: I strongly supported the need for government to invest in global change research over the long term; I also supported the policy intent of the WCPG with respect to urban regeneration in Cape Town, and I have for many years been concerned about the negative political consequences of the 'wait-for-the-grid' approach to in-situ upgrading of informal settlements. This was the 'contexture' of my role as a researcher: I was acting in various capacities, namely from active participant and facilitator to expert researcher who deployed the transdisciplinary research methodology. Denial to escape this paradox is not an option; it can only be recognised and incorporated into the analysis offered here.

Case 1: Global Change Grand Challenge

The Department of Science and Technology (DST) is a national government department responsible for the formulation of long-term policies and strategies aimed at supporting the transition from a resource-intensive to a knowledge-based economy.

In its long-term policy framework for accelerating innovation entitled *Innovation Towards a Knowledge-Based Economy 2008-2018*[17] the DST defined five 'grand challenges' that would then guide future investments in science and technology. One of these challenges was that of global change science, with a focus on climate change and a broader interest in transition to a more sustainable mode of economic production and consumption.

Significantly, the document entitled *Global Change Grand Challenge National Research Plan*[18] that was completed in June 2009 contains the following key sentence:

> *An inclusive process involving a wide cross-section of the science and policy communities in South Africa was followed to develop a detailed implementation plan for the first of these, i.e. enhancing our scientific understanding. This process has culminated in the development of this 10-year national research plan for the Global Change Grand Challenge (the Global Change Research Plan).*

Unfortunately, this 'inclusive process' is not discussed any further. The assumption created by this report is that the Global Change Grand Challenge (GCGC) unproblematically reflects a consensus reached by 'the science and policy communities' that participated in the various levels of engagement, i.e. the 'lead editors' who wrote the document, the 'editorial panel' comprising eminent academics who played an oversight role, and the 'contributing authors'. The key actors were drawn from the Council for Scientific and Industrial Research (CSIR) (which is a government-controlled and funded 'science council'); the National Research Foundation (NRF) which is a government agency that manages government funding for scientific research undertaken mainly by universities (specifically the South African Environmental Observation Network); officials from the DST; and academics from a select group of universities (with the Universities of Cape Town, Stellenbosch and Witwatersrand playing leading roles).

The 10-month process over 2008/2009 involved the following:

- intensive initial meetings between DST and CSIR to finalise a Terms of Reference;

- a series of facilitated consultative discussions and workshops involving about 50 scientists, most of whom were drawn from the CSIR, but with significant involvement by academics from various universities;

- submissions of written proposals from most of the participants, mostly referring to general conceptual issues but also practical implementation challenges related to expenditure and integration;

- intensive cycles of drafting and redrafting following comments submitted by participants;

- final approval by the DST and the Minister of Science and Technology.

The end result was a research framework divided into four themes as depicted in Table 1.

Significantly, the 'Understanding a changing planet' and 'Reducing the human footprint' themes reflected the research foci of the natural scientists, and there were already substantial funding pipelines in place for this research. The other two themes were unfunded and reflected the perspectives of those mainly interested in the economic and social dimensions of sustainability transitions.[19]

The process described above that led up to the formulation of the GCGC plan cannot be described as a research-based policy formulation process. Nor did it come remotely close to the notion of co-produced knowledge to address a real-world problem as envisaged by the transdisciplinary approach. It was, instead, more like a carefully staged policy negotiation process to craft a script that would protect and enlarge existing funding flows for Themes 1 and 2 and create new funding flows for Themes 3 and 4 (Table 1).

Themes 1 and 2 summarise the essence of the earth system science portfolio managed largely but not exclusively by the Applied Centre for Climate and Earth Systems Science (ACCESS) which is, in turn, managed by the CSIR. As a major consortium of universities and state-controlled research agencies/councils, ACCESS is South Africa's pre-eminent global change initiative within the natural sciences. It aims to secure an annual budget of EUR10 million. However, it does not address Themes 3 and 4. Hence those interested in opening up new funding flows to address the issues raised under Themes 3 and 4 needed to mount convincing arguments about the need to extend the scope of global change research beyond the traditional boundaries of earth system science.[20-22]

Besides the link between funding flows and policy arguments, there were four other aspects of the policy-formulation process that are worth noting, which shed light on the role researchers play as the stage managers of the science–policy interface:

- Competing conceptions of global change. As the majority of researchers involved were from the natural sciences and associated with ACCESS, they shared the earth system perspective on global change[20] which emphasises the importance of understanding extremely rapid changes in the global earth system. However, there was a minority of mainly social scientists whose conception of global change drew on material flow analysis[23], the Multi-Level Perspective[24,25] and the economics of socio-technical transitions[26], which emphasises the complex dynamics of transition and the importance of sustainability-oriented innovation systems[23]. In the end, the earth system perspective was reflected in Themes 1 and 2, and the transition perspective was reflected in Themes 3 and 4. Unsurprisingly, the bulk of the funding was allocated to Themes 1 and 2.

- Tension between research for deepening the understanding of systems and transdisciplinary research for co-producing knowledge. The failure to allocate funds later on for Research Chairs dealing with global and national sustainability transitions using a transdisciplinary approach (Theme 4) reflects the lower priority enjoyed by the transition/sustainability perspectives despite government policy commitments to a green economy and transition to sustainable development. Furthermore, in the first call for proposals for the first national research conference on global change (26–28 November 2012) issued by the NRF and DST, none of the transition themes (in Themes 3 and 4) were listed as topics for paper submissions. After objections, this was later changed to include the full span of topics.

- Limited involvement of the policy community. Besides the ongoing involvement of Imraan Patel, a senior DST official, there is little evidence that key policymakers within the DST and other government departments affected by the GCGC plan (such as the Department of Environmental Affairs) were involved in the policy formulation process.

- Weak connections to the private sector and civil society. The private sector and civil society stakeholders were effectively excluded from the process, despite considerable experience and expertise in connecting innovations to implementation.

In conclusion, the process of formulating the GCGC was stage managed by a tightly networked group of researchers with a vested interest in reproducing a policy framework that favoured funding flows into research programmes that they managed. This situation was certainly true of the earth systems research community, whereas the transitions research community – which included myself – aspired to secure these funding flows. Although nominally a partnership with the 'policy community', the DST set the stage for the performance but did little to guide it. The script and performance was carefully orchestrated primarily by the CSIR to

Table 1: Research framework outlined in the *Global Change Grand Challenge National Research Plan*

Understanding a changing planet		Reducing the human footprint		Adapting the way we live		Innovation for sustainability	
1.	Observation, monitoring and adaptive management	1.	Waste minimisation methods and technologies	1.	Preparing for rapid change and extreme events	1.	Dynamics of transition at different scales – mechanisms of innovation and learning
2.	Dynamics of the ocean around southern Africa	2.	Conserving biodiversity and ecosystem services, e.g. clean drinking water	2.	Planning for sustainable urban development in a South African context	2.	Resilience and capability
3.	Dynamics of the complex internal earth systems	3.	Institutional integration to manage ecosystems and ecosystem services	3.	Water security for South Africa	3.	Options for greening the developmental state
4.	Linking the land, air and sea			4.	Food and fibre security for South Africa		
5.	Improving model predictions at different scales						

Source: Department of Science and Technology[18]

direct research funding along distinct pathways. Unsurprisingly, there is little evidence that this policy process was influenced by transdisciplinary methods of co-production of knowledge for innovation.

Case 2: Cape Town Central City Regeneration Initiative

In contrast to the researcher-driven GCGC process, the Cape Town Central City Provincial Government Regeneration Initiative (henceforth CTRI for short) was initiated by the Provincial Minister of Transport and Public Works. The initial policy formation phase, led by key officials in his department, occurred between December 2009 and May 2010.[27]

After his appointment as the WCPG's Minister of Transport and Public Works, Robin Carlisle initiated an informal networking process with a few individuals within and outside government to formulate a terms of reference for what eventually became the CTRI. He decided to build on two existing partnership agreements: one with the Cape Town Partnership led by Andrew Boraine and the other with the Cape Higher Education Consortium (CHEC) led by Nasima Badsha. The Cape Town Partnership is a non-profit that was established in 1999 as a partnership between the City of Cape Town (CCT) and the South African Property Owners Association and has spearheaded the regeneration and marketing of Cape Town's central business district (CBD). CHEC is also a non-profit established by the four Western Cape universities to coordinate joint activities, in particular collaborations with the WCPG and CCT.

CHEC was contracted by the Department of Transport and Public Works (DTPW) to constitute a Steering Committee that would assist the department's Regeneration Team, led by Francois Joubert, to formulate the overarching policy framework. Academics mainly from the Universities of Stellenbosch, Western Cape and Cape Town were drawn in, plus Andrew Boraine and Nasima Badsha, as well as well-known architects and planners from the consulting world, namely Mokena Makeka and Barbara Southworth (who was previously head of planning in the CCT).

The initial strategic intent of the CTRI was to catalyse an impactful urban regeneration initiative that would simultaneously double the floor space of the CBD with major economic consequences *and* resolve a key financial problem facing the DTPW. This case arose because the department was responsible for a large stock of government buildings that were not only dysfunctional as office buildings, but also more expensive to operate than what it would have cost to lease the buildings from the private sector. The Minister's vision was that strategically located public assets could be re-invented and then used as leverage (via sale or renovation) to catalyse large-scale private sector investments in urban regeneration within the precincts where the public sector buildings are located.

The primary task of the Steering Committee was to write up this proposal in the form of a policy document. Although the time period was too short for this task to be a genuine transdisciplinary research process, real expertise from different sources was mobilised and integrated via a set of discovery-oriented engagements that did result in significant debate, exploration and synthesis. The process involved the following engagements:

- regular meetings of a core coordination group;

- less regular, broader and more formal meetings of the Steering Committee to brainstorm key ideas and strategies (these meetings were the most crucial turning points in the process);

- increasingly frequent meetings later in the process which involved consultants working on the drafting of the policy document;

- research work undertaken mainly by Masters student Katherine Hyman[24] to collect and read key planning documents, especially those regarding infrastructure;

- ongoing informal interactions with key stakeholder groups from the private sector, consulting industry and CCT;

- a crucial stakeholder workshop on 9 April convened by CHEC that brought in key players from the property development industry, consulting firms, CCT, WCPG and the universities to discuss what was by then a draft policy framework;

- intense interactive engagements during the drafting phase which was concentrated into the months of April and May 2010.

Although the DTPW did not initially assume that sustainability was going to be an integral part of the argument and vision of the final policy document, it gradually became clear that there would be one overriding obstacle to the achievement of the vision, and that was the lack of an adequate urban infrastructure (specifically with respect to energy, solid waste, transport, water and sanitation). In contrast to what the consultants and some officials were saying, further research by the academics showed that there were real infrastructure constraints and that solutions using 'business-as-usual' technologies would be prohibitively expensive. This conclusion opened up the space for the introduction of a sustainability perspective, referring specifically to new technologies for treating sewage, using water more efficiently, designing and operating energy-efficient buildings, generating renewable energy, recycling solid waste and introducing non-motorised mobility and public transport.

However, it would be incorrect to ignore the fact that the WCPG and the CCT had over the previous several years evolved a range of policy and strategy documents that expressed commitments to a more sustainable use of resources and less negative impacts on the natural environment.[28-30] These documents created a legitimating language that key politicians, such as the Premier of the WCPG, tended to draw on to express future visions and plans. The dense network of NGOs and university-based researchers that deal with sustainability issues in Cape Town also have strong working relationships with the WCPG and the CCT. These relationships, together with the existence of influential business-linked groups interested in sustainability (e.g. Cambridge Programme for Industry, Accelerate Cape Town, Sustain Our Africa), have built up an accepted body of expertise and general awareness that infuses public and policy discourse. Without this discursive environment, it would not have been possible to introduce specific ideas into the CTRI policy document about sustainability-oriented urban infrastructure alternatives.

The final document was handed over to the DTPW on 17 May 2010, paving the way for phases 2 (precinct planning) and 3 (implementation) of the project. The final version captured a vision for the central city as a space that needs to be productive, connected, innovative, cohesive, sustainable and safe. In October 2013, the first major Brownfields Redevelopment Initiative was announced to realise the CTRI vision, namely the so-called Two Rivers Urban Park project envisaged for a 300-ha area largely owned by state agencies. This particular project emerged from a group of officials at provincial and city level working with key individuals from the universities and the private sector.

In conclusion, this case is about a knowledge partnership actively solicited and led by a government department (with full political support) that involved universities, the property development sector and consultants in a process that was not just about negotiating language to express a consensus to satisfy a political perspective. What mattered was not merely the content of the final report (the script), but also the setting (meetings at CHEC offices and offices of the private sector) and the process (input from the university and property development sectors) which validated and legitimised the final product. A rapid process of interactive discovery and debate informed by intensive information gathering and stakeholder engagement made it possible to co-generate a policy framework that has continued to inspire subsequent work and retain political support. Researchers were given space to investigate, raise questions, criticise the findings of consultants and facilitate learning processes that formed part of the joint planning process. Given the complexities, in this case our advocacy was informed by our research rather than the other way round.

Key criticisms would be the absence of involvement of non-governmental organisations or broader civil society sectors, and the fact that the CCT

was only brought into the process towards the end which resulted in implementation delays.

Case 3: Incremental upgrading: The iShack initiative

Soon after 1994, the South African government introduced an ambitious housing programme to address the legacy of apartheid. The result was the construction of 2.9 million houses by 2010 – one of the highest rates of housing delivery to the poor in the world. Nevertheless, shrinking household sizes and population growth meant that by 2004, the housing backlog had grown from 1.5 million to 2.1 million housing units. To make matters worse, houses were built on cheap land to reduce costs, resulting in the bulk of housing being located on the urban peripheries far from places of employment and access to services. This peripheral location of low-income settlements resulted in the ballooning of bus transport subsidies to offset the rising costs of getting them to work and exacerbated household poverty in these settlements.

To remedy this problem, a new housing policy was introduced by the Department of Human Settlements in 2004 called *Breaking New Ground: A Comprehensive Plan for the Development of Sustainable Human Settlements* (commonly referred to as BNG). A key component of this new policy was acceptance of the need for in-situ upgrading of informal settlements rather than relocating them. This policy resulted in what is now called the Upgrading of Informal Settlements Programme (UISP). The Minister of Human Settlements signed his performance agreement with the President in 2010 which committed him to the upgrading of 400 000 shacks by 2014.

In early 2011, a group of postgraduate students decided to focus their research on an illegal informal settlement of 6000 people called Nkanini (which means 'take by force'), located within walking distance of Stellenbosch.[18] The initial research question was: what does in-situ upgrading (as specified by the UISP) mean in practice from the perspective of the average shack dweller living in Nkanini? A transdisciplinary research methodology was adopted, but it was recognised from the start that the relevant formal stakeholders could not be identified as required by mainstream transdisciplinary approaches. Instead, direct relationships needed to be established with the community, which included students moving into the community to experience living in a shack, building relationships with individuals and mounting visible campaigns such as the painting of shacks using bright colours and designs. Contact was made with the Informal Settlement Network (ISN), which is a social movement active in the Stellenbosch area, supported in turn by Shackdwellers International (SDI) (www.sdinet.org). A working relationship of sorts was also established with relevant officials in the Stellenbosch Municipality who were, in turn, working formally with ISN/SDI.

It became apparent early on that in practice, the UISP means delivery by the municipality (subject to funding from higher levels of government) of electricity (street lights only), water, sanitation, roads, and stormwater and solid waste services. However, this service provision can happen only if the settlement has been legally recognised as permanent and the land has been rezoned as residential. Neither of these conditions were met in the case of Nkanini: it is one of the few informal settlements in South Africa which has been formally declared illegal and therefore needs to be removed – a threat that has never been carried out. Even if Nkanini were legally entitled to be there, then in-situ upgrading would in practice mean waiting for the electricity and water grids to arrive, with minimal services for solid waste collection in the meantime. The WCPG has calculated that on average it takes 8 years after legalisation or rezoning for communities to be connected to the electricity and water grids after formal commencement of the upgrading process. Even then, all the community is likely to receive is street lighting, not electrical connections to each unit.

In short, the problem statement became: upgrading means 'wait for the grids to arrive'. The research question became: what could be done between now and the arrival of the grids to improve quality of life? The fact that development has come to mean 'trust and wait' effectively demobilises civil society because there is nothing to organise communities around that can result in tangible, immediate improvements to daily life. Instead, activists discover where the state intends delivering next and stay one step ahead by organising people around what is going to get delivered anyway in a uniform top-down manner. This situation is not only a recipe for a weak civil society, but also effectively undermines democracy. This scenario contextualises the significance of the transformation-oriented research question. Note how different this approach is to the most common research questions asked about informal settlements, namely 'why do they exist?', 'what are the living conditions?' (which are both about systems knowledge) or, occasionally, the target knowledge question, 'what is the solution?'. 'What can be done now by members of the community?' is a transformation knowledge question.

After many months of informal interactions with the community, officials and ISN, and informed by initial research on UISP and BNG, it was decided that ecological design methods may open up an alternative way of thinking about a genuine incremental approach to upgrading, one that avoids all the negative consequences of the 'trust and wait' approach. Working with engineers and an ecological architect, a design was generated for an 'improved shack' – the 'iShack'[31,32]. This design amounted to a 14.2-m^2 shack that included:

- insulation in the walls and roof, covered with cardboard painted with fire retardant paint;

- a thermal mass for passive heating and cooling by using a 1-m high adobe wall along the back of the shack together with a floor made from fired clay bricks reclaimed from the landfill;

- a north–south orientation plus a roof overhang on the north side for shade in summer and solar penetration in winter;

- correctly sized and located windows for lighting and ventilation;

- a 25-W solar panel to power three LED lights and a cell phone charger;

- a gutter to capture rainwater.

Working with an informal group of local leaders and with permission from the local authority, a very poorly built wooden shack inhabited by a single mother with three young children was identified for replacement. After building a new iShack for her, the old shack was demolished as required by the local authority. A neighbouring shack was retrofitted with insulation and a solar unit. Environmental monitoring equipment was installed in both shacks, plus a neighbouring non-retrofitted shack in order to generate comparisons. The results showed conclusively the benefits of the intervention, which included 4–6 h of extra thermal comfort each day, reduced fire risk and improved lighting.

Four rather dramatic consequences flowed from the erection of the iShack, the retrofitting of two neighbouring shacks and related research on sanitation and solid waste. Firstly, a process of social mobilisation within the community started to take place around demands for incremental upgrading. The core group of community members who worked with the students accumulated skills and knowledge, including attending training modules paid for by the project. In other words, what started off largely as a rather limited technical intervention spiralled out into a wider community mobilisation process. Secondly, the Bill and Melinda Gates Foundation (which also funds the international work of SDI) requested a funding proposal to take the work forward, resulting in a grant of USD 250 000 in June 2012. Thirdly, the government's Green Fund decided to allocate another R1.7 million to help the project reach scale. Fourthly, in 2013, the Stellenbosch Municipality changed its indigent policy to provide for the transfer of the free basic electricity subsidy to non-grid connected shack dwellers – an unprecedented innovation. In addition, the iShack project has attracted extensive media attention in the mainstream and local press and resulted in four television appearances.

Driven by problem-solving research, the envisaged end result is a viable social enterprise that makes it possible to organise informal settlements

around tangible material improvements. Once a community realises the benefits of cooperative action, they will have in place social and institutional structures that will make it possible to continue to struggle for further improvements, such as secure land rights and access to subsidies for housing.

Some officials and SDI staff have openly criticised the researchers for crossing the boundary between being researchers and becoming activists. Others have argued that it is possible to be a researcher-activist: that is to use research to articulate alternatives and win ground as an activist. Because this transdisciplinary process is taking place within such a volatile context of highly unequal power relations, the dramaturgy of the process has become a key focus of attention. Compared to the contestations over who stage manages the process and related performances (researchers versus officials versus SDI staff versus community leaders), the script itself is almost irrelevant. Yet it was the technical breakthroughs about alternative infrastructure solutions, derived from interactions with particular groups of shack dwellers, that produced the social effects, including recognition that Nkanini was there to stay. In short, a limited well-managed process has triggered a secondary and much wider drama involving a set of players that have political agendas that may be incompatible with the original vision of community empowerment.

In conclusion, the iShack case demonstrates how researchers can actively engage with communities to co-produce solutions to real-world problems. Yet they are part of wider processes that they can ill afford to be naïve about. By adapting the transdisciplinary research methodology to this specific context, researchers actively perturbed the social fabric of everyday life to demonstrate a viable alternative to the state's top-down approach to in-situ upgrading. Instead of a 'trust and wait' approach, an authentic incrementalist approach emerged. It was only after the model was demonstrated and elaborated that it was possible to formalise a working relationship with the other stakeholders to upscale the model. A transdisciplinary research approach has continued to be implemented with issues such as sanitation and solid waste removal included in the research agenda with equally dramatic social effects. The challenge, however, has been to ensure that researchers and the community-based co-researchers remain reflexive about their roles at all times. Success can breed an arrogance that undermines the humility needed to effectively engage the complex power dynamics that saturate communities like Nkanini. Self-conscious recognition of the power of the script to shape the settings and performances in this particular contexture will determine whether the researchers will be able to continue to work in such an embedded manner in future.

Conclusion

It was argued at the outset that the reflexive approach is interested in contextualising the dramaturgy of deliberative policy processes to reveal the limits of rote practices that result in meaningless formalistic outcomes. Meanwhile, the transdisciplinary approach mounts a normative argument in favour of researchers as co-producers of problem-solving knowledge. While the former focuses on roles and discourse, the latter focuses on methodologies and methods for practically realising co-production. It was suggested that both are needed to understand how researchers engage in real-world policy processes about sustainability-oriented innovations. Those who advocate the transdisciplinary approach need to be more reflexive, and those who argue for reflexivity may need to take more seriously the importance of particular methodologies and methods of actual co-production.

The three cases reveal the degree to which researchers become advocates and how they operationalise knowledge partnerships. The case narratives help to highlight the paradox faced by researchers who are both active performers within particular settings and the designated script writers with a responsibility to analyse and facilitate understanding. Whereas research was merely supportive of pre-determined positions in Case 1, in Cases 2 and 3, in which the outcomes were less clear at the outset, research was able to inform and shape the end result. Case 1 demonstrated a more traditional approach with very limited co-production of knowledge, but with researchers advocating specific policy

frameworks that simultaneously served their own institutional interests and put in place a 10-year government commitment to fund what is South Africa's first coherently structured sustainability-oriented research agenda. It is significant that this plan combined earth system science and sustainability transitions perspectives, with the bulk of funding going towards the former.

In Case 2 a significant degree of co-production of knowledge involving public, private and university-based stakeholders took place, with researchers playing less of an advocacy role as a result of strong leadership by government officials. Although private sector stakeholders were engaged, civil society stakeholders were excluded. Sustainability was not initially emphasised, but over time researchers played the key role in revealing the need to broaden the script to include sustainability-oriented innovations with respect to future urban infrastructure investments. The settings and processes of engagement were conducive for learning in this regard.

Case 3 was explicitly motivated by a transdisciplinary co-production approach involving a particular community in which researchers acted as both knowledge producers and as advocates for a particular sustainability-oriented solution. Unlike Cases 1 and 2, government was not initially a participant in the process. Nor was it possible to assume the existence of a formalised setting for engagements between organised stakeholders, because none of these conditions existed prior to the process. However, the impact of the original research results triggered a much wider secondary drama that transformed what was a limited technical intervention into a much wider social mobilisation and institution-building process.

To conclude, further research is needed on the micro-dynamics of the actual science–policy interface. This work should entail reflexive research that analyses the interactions of the actors themselves, paying particular attention to the dynamics of problem identification, knowledge production and problem solving, and the roles played by particular actors as performance changes require changes in the script. This analysis, in turn, will help implementers of the transdisciplinary approach to become more critically aware of their actual roles, impacts and unavoidable biases. These three cases reveal how important it was for researchers to actively engage in policy processes to achieve particular outcomes that may not have been achieved without the learning that research makes possible. But it would be naïve to ignore that these processes are saturated by the dynamics of power, institutional interests and agenda setting by researchers themselves and by key players that researchers can rarely control or counter.

Engagement will always come at a price. The key to balancing the cost is how reflexive researchers will be in analysing their own practices and mistakes as they navigate ever-changing scripts, stagings and performances as they learn to use transdisciplinary methodologies and methods.

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