



Government
Office for Science



Coping with change: urban resilience, sustainability, adaptability and path dependence

Future of cities: working paper

Foresight, Government Office for Science

Coping with change: urban resilience, sustainability, adaptability and path dependence

Michael Thompson
International Institute for Applied Systems Analysis

and

M. Bruce Beck
University of Georgia

December 2014

This review has been commissioned as part of the UK Government's Foresight Future of Cities Project. The views expressed do not represent policy of any government or organisation.

Contents

Foreword	4
Introduction.....	5
1. The systems theory framing: wicked problems, uncomfortable knowledge, clumsy solutions ...	7
2. Rat-infested slums transformed into glorious heritage	11
2.1 Mapping the moral positions: the contested terrain	12
3. Near-destitute Maoist insurgents transformed into increasingly prosperous market gardeners	20
3.1 Escape from elegance.....	21
3.2 Who benefits?	22
4. What does this framing, and these examples, tell us about urban resilience, sustainability, adaptability and path dependence (and how does that differ from current understandings)?	24
4.1 Sustainability.....	24
4.2 Resilience	28
4.3 Adaptation.....	31
4.4 Path dependence	32
5. Finally, connecting the systemic dots.....	36
5.1 Clumsiness and computational foresight	36
5.2 A candidate challenge: smarter urban metabolism	38
References	40

Foreword

The Future of Cities project is informed by working papers which are commissioned by the [Lead Expert Group](#) and written by authors from academia and industry.

These papers highlight the key challenges and opportunities facing cities in the UK out to 2065. The Expert Group will draw upon this evidence base to develop project outputs which will be published in 2014 and 2015.

These outputs will aim to inform near-term policy making in both local and central government, which achieves desirable long-term outcomes for UK cities.

Professor Sir Alan Wilson

Introduction

About 12 years ago, Arsenal Football Club decided they really *would* have to do something about their Highbury stadium. It only held 30,000 spectators and they needed double that. Also, the pitch was slightly under-sized and this detracted from their status as one of the premier clubs in the world. Thus it was that Arsenal (we'll call it the *market actor*) sidled up to Islington Borough Council (we'll call it the *hierarchical actor*) with the suggestion that the council give the go-ahead – “outline planning permission” – for Arsenal to acquire, and demolish, the two streets of houses immediately adjacent to its stadium, thereby enabling it to expand its capacity to 60,000, along with a full-sized pitch.

Most of social science (especially in relation to public policy and urban governance) assumes that that is it: if it isn't the market it's the hierarchy, and *vice versa* (as, for instance, with financial sector firms and financial regulators, or Margaret Thatcher's attempt to create an “enterprise culture” by laying into the unions, the professions and other bastions of privilege and restrictive practices). But it isn't! Within less than 24 hours of Arsenal's approach to Islington Council becoming public knowledge, a third actor emerged: the Highbury Community Association. Its members were implacably opposed to the solution Arsenal was proposing: the *only* solution, Arsenal insisted, playing what it thought was its trump card, if the club was to remain in the borough.

So this third actor – we'll call it the *egalitarian actor* (its arguments being largely couched in terms of the unfair treatment of residents, small local businesses, the unemployed and so on) – really put the cat among the pigeons. An enormous controversy blew up, a petition with thousands of signatures was delivered to Islington Town Hall, and there was a vigorous television debate (chaired, very well, by the former government minister, Ann Widdecombe). It soon became clear, trump card or not, that there was no way Arsenal was going to get permission to expand on its Highbury site. Various alternatives were then proposed – one of which was to re-locate to a vast regeneration project, just a couple of miles away, around King's Cross and St. Pancras stations – but none proved to be feasible. So it began to look as though Arsenal had indeed been right and that the club, to the dismay of both the council and its loyal supporters, would indeed have to move right out of the borough: all the way out to near the M25 orbital motorway.

But then two commercial property surveyors, who also happened to be fanatical Arsenal supporters, got out their maps. To everyone's surprise (including theirs) they found a triangular piece of rather low-rent and under-used land, bounded on two sides by busy railway lines, that would comfortably take a 60,000-seat stadium. Even more amazingly, as well as being already owned by the council, it was less than half-a-mile away from the old stadium and its hallowed (but under-sized) turf! Cutting a long story short, in August 2006 – just four years later, on-time and on-budget – Arsenal moved into its new stadium: onto this near-ideal site, the very existence of which had remained entirely unnoticed until the three-cornered battle – the market actor, the hierarchical actor and the egalitarian actor – had been joined.

So this is a nice example of what is now called (with tongue in cheek) a *clumsy solution*: a solution that, in contrast to the familiar *elegant solutions*, emerges only in those situations where each of these three kinds of actor is (a) able to make itself heard (*accessibility*) and (b) then responsive to, rather than dismissive of, the others (*responsiveness*). Things, we can now see, started off over-elegant (just Arsenal and Islington Council); they only became clumsified when the third actor – the Highbury Community Association – managed to force its way in.

Moreover, in a clumsy solution – and this is the counter-intuitive bit – each actor ends up with more of what it wants (and less of what it doesn't want) than it would have got if it had somehow managed to achieve “hegemony” and impose its distinctive (and elegant) solution.

- *Arsenal* (the market actor) has got its state-of-the-art stadium (and a handsome price for its old stadium, which has now been re-developed, mostly for housing).
- *Islington Council* (the hierarchical actor) has kept the club in the borough (and extracted a colossal “planning gain”: thousands of new houses, a futuristic waste-transfer and re-cycling centre, some badly-needed public open space and so on).
- *The Highbury Community Association* (the egalitarian actor) has saved the streets and houses around the old stadium, and forced the council to ensure that those businesses displaced by the new stadium were re-located within the borough, and without any loss of jobs. Of course, they are still critical, especially over the failure to build a new tube station within the stadium (the Piccadilly Line passes directly beneath it) but they do have the satisfaction of knowing that the new stadium is the greenest in the world! (For a more detailed account see Thompson 2008, ch. 1).
- Even the disregarded *fatalist actors* – the “cannon fodder” supporters who find their way on foot, stopping off at their favoured pubs and chip shops – have done quite well. Reaching the new stadium is still feasible, whilst they could never have made it to an out-of-the-borough venue.

So our argument, in a nutshell, is that we need to ensure that every decision – every essay at coping with change – mimics what happened with Arsenal's new stadium. In that case, of course, the clumsy solution came about *by accident*: the rude intrusion of the initially excluded egalitarian actor turning out to be so constructive. The challenge is to get it to happen, every time, *by design*!

But why, it might be objected, if it is as easy as this, do we not see clumsy solutions all over the place? The answer (as we hope will become more apparent when we get to our case studies) is that the two necessary conditions – accessibility and responsiveness – are not easily achieved. Indeed, the four precepts of policy analysis – (a) insist on a single agreed definition of the problem, (b) clearly distinguish between facts and values, (c) set up a “single metric” (pounds, lives saved, etc.) so as to be able to compare and evaluate options, and (d) optimise around the best option – together ensure the silencing of all but one actor. So, if we want to find our way to clumsy solutions, we will have to insert the words “do not” in each of those precepts. And that, outrageous though it may appear, is what we are proposing.¹

¹ For a more reasoned justification for this proposal, together with an explanation for why it is now being seen as less outrageous, see the concluding chapter of Verweij and Thompson (2011).

I. The systems theory framing: wicked problems, uncomfortable knowledge, clumsy solutions²

With *wicked problems* (climate change is currently the prime example), and in marked contrast to *tame problems* (the hole in the ozone layer, for instance, to which climate change is often, and erroneously, compared), there are contending and mutually contradictory definitions of the problem-and-solution, and these do not converge as the policy process gets under way. If they are treated as tame problems then the assumption of a single definition imposes elegance, but at a cost: the exclusion of those actors who subscribe to the other definitions. The valid and useful knowledge generated by these excluded actors, since it inevitably calls into question the knowledge that is generated by the “hegemonic” actor, is then seen as *uncomfortable* and is ignored or marginalised (for instance, by labelling it “voodoo science”). If that is to be avoided then things will have to be arranged institutionally so that each of the “voices” is able to make itself heard and is then responsive to, rather than disdainful of, the others. Only then will we see the emergence, as happened with Arsenal’s new stadium, of those more robust, consent-preserving, surprise-lessening and inherently democratic outcomes: clumsy solutions (see Box A: Our Framing’s Origins and Underpinnings).³

Another way of casting this systems theory framing is by way of the distinction between the well-known methods of DMUU (Decision Making Under Uncertainty) and the as yet largely unacknowledged DMUCC (Decision Making Under Contradictory Certainties). In the former, uncertainty is simply the absence of certainty (and its methods proved most effective in dealing, via the Montreal Protocol, with the hole in the ozone layer); in the latter, there are different “social constructions” of the problem that are mutually irreducible and mutually sustaining (those, like Kofi Annan and Nicholas Stern, who see climate change as a massive instance of market failure, have no common ground with those, like the members of the uncompromising environmental group World Rainforest Movement, who pin the blame on the capitalist system *per se*; see Douglas et al 2003)⁴. However, these contradictory certainties do not require that water flows uphill, or that the

² “Wicked problems, uncomfortable knowledge, clumsy solutions” became the byline, in the mid-2000s, of Oxford University’s James Martin Institute for Science and Civilization. Steve Rayner, the institute’s director, presided over the long and arduous process by which it was arrived at (see Rayner 2012).

³ Our framing, as is evident in our focus on “voices” (in the plural), is in terms of *Soft Systems Theory*. It starts from the assumption that our engagement with whatever it is that is “out there” is always mediated through “perspectives”, “lenses”, “Weltanschauungen”, “social constructions”, and so on (see, for instance, Checkland 1985). However, rather than just insisting there will always be a plurality of perspectives, we draw (as in our Arsenal example) on the *Theory of Plural Rationality* (also called *Cultural Theory*) and its typology of perspectives/forms of social solidarity: four ways of organising – individualism, hierarchy, egalitarianism, and fatalism – each of which is, at the same time, a way of disorganising the other three.

This theory, which originated with Mary Douglas’ *Natural Symbols* (1970), “now rivals the rational choice, Weberian, and postmodern outlooks in terms of influence across the social sciences” (6 and Mars 2008: xv). Its relationship to these other outlooks, unsurprisingly, is not straightforward, being a mix of disagreements and subsumations (see, in addition to 6 and Mars 2008, “Part Two: The Masters” in Thompson et al 1990 and chapter 8, “Heinz Minus Seven: The Fifty Varieties of Social Science” in Thompson 2008). Nor, again unsurprisingly, has this theory gone uncriticised. The principal criticisms (some of which are mutually contradictory – the pluralism is too great *versus* too limited, the theory is deterministic *versus* insufficiently deterministic) are assembled, and largely refuted, in 6 and Mars (2008: xxiii-xxvii).

⁴ In an article in *The Independent* (London, 9 November 2006) Kofi Annan, quoting Lord Stern, described climate change as “the greatest and widest-ranging market failure ever seen”. The World Rainforest Movement, in contrast, issued a strident “Call to Action” at the COP20 Lima Climate Conference (December, 2014): “To Reject REDD+ and Extractive Industries. To Confront Capitalism and Defend Life and Territories” (http://wrm.org.uy/wp-content/uploads/2014/11/Call-COP-Lima_NoREDD.pdf; last accessed, 4 December, 2014).

laws of thermodynamics be re-written; they are all (usually) contained within the wide uncertainty that typically accompanies wicked problems (see, for example, Verweij 2011).⁵ In order to demonstrate the import of our framing, we will now provide two “worked examples” of DMUCC in relation to cities: the first, some 50 years ago, in the centre of a developed world city, London; the second, just a few years ago, on the periphery of Kathmandu, the capital of a least-developed country, Nepal. As well as their obvious developmental differences, these two cities, as we will see, come out very differently in terms of path dependence.

Box A: Our framing’s origins and underpinnings

Wicked problems were first delineated, more than 40 years ago, by two Berkeley political scientists: Horst Rittel and Melvin Webber (Rittel and Webber 1973). Wicked problems have several inter-related characteristics and, as a result of these characteristics, people typically clash over how to *define* them and over how to *resolve* them:

- The range of possible causes is large and uncertain (as are the possible interactions of those causes).
- The range of possible solutions is equally large and uncertain.
 - Every solution is a “one-shot operation” and will have serious consequences (there are, in other words, considerable “sunk costs”, and this means that a decision – to build a super-sewer, say, or a high-speed rail link – cannot easily be backed out of if things do not go quite as expected).
 - Many people, organisations and social domains are involved.
 - Wicked problems are essentially unique and novel.
 - They have no “stopping rule” (every attempt at resolution leads to new problems).
 - There are no absolutely right solutions.

In his book *Clumsy Solutions for a Wicked World* Marco Verweij (2011) checks climate change and the ozone hole against those seven characteristics, thereby confirming that the former is a wicked problem and the latter a tame one. That is the copper-bottomed test for this crucial distinction; usually (as is shown in Thompson and Gyawali 2007) the existence of plural and mutually incompatible definitions of problem and solution, together with their non-convergence as the policy process gets under way, suffices.

Uncomfortable knowledge. The well-known academic response “New not true; true not new” nicely captures the way in which the members of a scientific establishment tend to “adjust” knowledge that threatens the paradigm around which they are stabilised. The philosopher of science, Imré Lakatos (1976), in his book *Proofs and Refutations*, showed that “monsters” – pieces of knowledge that cannot be accommodated within the prevailing paradigm – can occur even in mathematics, and he went on to tease out the various ways in which this sort of uncomfortable

⁵ For an instance (the hierarchical actor, as it happened, in relationship to environment and development in the Himalayan Region) of a certainty straying, thanks to its unchallenged hegemony, into the “re-write the laws of thermodynamics” zone, see Ives 2004.

knowledge can be handled: by *monster-adjusting*, for instance (in which both the paradigm and the offending piece of knowledge are progressively modified until a fit, of sorts, is achieved) or by *monster-barring* (in which the offending knowledge, and its carriers, are rejected out of hand, as happened with the first attempts to publish Ohm's law: "these preposterous theories of Professor Ohm" was the response, and Ohm lost his university position). A topical example (as we have just mentioned) is the response by the head of the IPCC (the Intergovernmental Panel on Climate Change), Rajendra Pachauri, to the glaciologists who helpfully pointed out that a recent IPCC report had made a serious mistake in its predictions about the rate at which Himalayan glaciers are retreating. He called them "voodoo scientists" (others have even found themselves stigmatised as "climate change deniers"). Quite independently of Lakatos, the anthropologist Mary Douglas (1970), in her book *Natural Symbols*, also homed-in on monsters: in her case these were animals – such as the pangolin, among her people, the Lele in the former Belgian Congo – that simply could not be fitted into the indigenous typology. A few years later David Bloor, a philosopher, in a celebrated article "Polyhedra and the abominations of Leviticus" (Bloor 1982), synthesised these approaches, thereby establishing a thorough-going theory of uncomfortable knowledge:

"The books [*Proofs and Refutations* and *Natural Symbols*] have a common theme: they deal with the ways men respond to things which do not fit into the boxes and boundaries of accepted ways of thinking; they are about anomalies to publicly-accepted schemes of classification. Whether it be a counter-example to a proof; an animal that does not fit into the local taxonomy; or a deviant who violates the current moral norms, the same range of reactions is generated." (Bloor 1982: 191).

Clumsy solutions originated, back in 1988, with Michael Shapiro, a lawyer at the University of Southern California. To be precise, he used the term "clumsy institution" (Shapiro 1988) so as to stress the good sense inherent in the seemingly messy way in which new members of the US Supreme Court are chosen. It is a way of escaping from the commonsensical prescription (enshrined, as we have seen, in those four precepts of policy analysis) that, when faced with contradictory definitions of problem-and-solution, we must choose one and reject the rest. The idea was subsequently picked up by a number of anthropologists and policy analysts (see, for instance, the case studies of elegant failures and clumsy successes in Verweij and Thompson 2011) and the term clumsy institution is now used to characterise the sort of "policy sub-system" in which those who speak with the four voices – the three we have encountered in the Arsenal story plus the somewhat muted fatalist voice – that are predicted by the theory of plural rationality (also called cultural theory) all enjoy both accessibility and responsiveness (Thompson et al 1990). Clumsy institution is thus the polar opposite of what Robert Dahl (1971) in his *Theory of pluralist democracy*, called "closed hegemony": The hyper-elegant situation in which just one voice drowns out the others. But, where Dahl had just his dualistic distinction – closed hegemony versus pluralist democracy – our typology of four voices gives us four distinct varieties of closed hegemony. It also enables us to recognise the seven (14 if we include the muted fatalist voice) different kinds of policy sub-system that populate the "excluded middle" between Dahl's two extremes. And, for good measure, this refurbishment of the classic theory of pluralist democracy makes clear that it is *discourse* – contending voices, narratives, storylines and so on – that is key. So we need methods that are very different from those that have been developed in terms of the precepts of policy analysis. We need methods that, by zeroing-in on the policy discourses, can tell us which voices enjoy accessibility and responsiveness and which ones, like Sherlock Holmes' dog that did not bark, are missing. In consequence, this 3 x 3 typology of

policy subsystems – Dahl’s two extremes and the seven that lie in his excluded middle – is now quite well established within what we might call “the new toolkit for policy in a complex and plurally perceived world” (see Ney 2009; Thompson 2008; also the section in our second paper headed “the new toolkit, etc.”).

2. Rat-infested slums transformed into glorious heritage⁶

There is a sort of orthodoxy nowadays which sees the material flows that we are generating as excessive and environmentally *unsustainable*. Carbon dioxide from fossil fuels, sand and gravel for construction work, mangoes being flown into Europe from Honduras, domestic waste demanding more and more landfill sites, pig slurry (rich in nitrogen and phosphorus) causing algae blooms in the North Sea ... on and on. Greed, thoughtlessness, a capitalist system out of control, the triumph of competition over cooperation, the inequitable relationship between the nations of the North and those of the South, and anthropomorphism – our domination of nature when what is needed is a self-effacing recognition that we are but one component within an intricately connected and inherently fragile ecosystem – are prominent among the reasons that are advanced for the material flows – the stuff that we are pushing around – being the way they are.

Societal metabolism – the way in which societies organise their exchange of matter and energy with their natural environment – is the umbrella concept for those who study these material flows (for example, Fischer-Kowalski and Haberl 1993, 1998; Schmidt-Bleek 1994; Ayres and Simonis 1994; Brunner and Rechberger 2003; Beck et al 2013). Since they are subject to conservation principles – neither matter nor energy being created or destroyed – these exchanges are typically expressed in terms of stocks and flows. And the aim is to build up a detailed picture of just what is going where as a result of our social involvement with our physical world. Sometimes the depletion of natural resources is the focus (for example, Meadows et al 1972); more recently the filling-up of available “sinks” (oceans, landfills ... the atmosphere) has come to the fore (for example, Meadows et al 1992). Taken together, these approaches to (or overshooting of) nature’s limits have now been framed in terms of a gross imbalance between that portion of the earth’s “primary product” that is appropriated by us humans and what is left over for the rest of creation (e.g. Vitousek et al 1986; Wright 1990). And this framing has now been further generalised in terms of a number of “planetary boundaries”: dangerous climate change, loss of biodiversity, gross distortions of the nitrogen and phosphorus cycles, and so on (e.g. Rockström et al 2009; Lynas 2011).

This orthodox framing of the problem, clearly, is being done from a moral position – indeed, the whole discourse takes the form of a sermon about our profligacy and what it is doing to our relationships with one another and with nature – and those who adopt that moral position, equally clearly, will be having some effect on the material flows. But, and this is where elegance needs to give way to clumsiness, there are *other* moral positions and *other* ways of framing the problem (see, for instance, the critique of the planetary boundaries framing of Nordhaus et al 2012). And it is this plurality of moral positions, and their modes of interaction, that are actually determining the material flows (those flows being, as it were, the resultant of the diverse forces that are being exerted by those who are gathered at each of the moral positions). This means that, if you are interested in the material flows, and in finding ways of altering those material flows, you will get nowhere until you have a map of those moral positions (Beck et al 2013). Put another way, sustainable development is never self-evident, as that famous Gro Harlem Brundtland definition would have you believe: “development that meets the needs of the present

⁶ For a more detailed version of this worked example (in German) see Thompson (2003a). An English version – “Material Flows and Moral Positions” – is available at <http://cfgnet.org/archives/531>.

without compromising the ability of future generations to meet their own needs” (WCED 1987). It is an *essentially contested concept* (Gallie 1955; Thompson 2011; see the section below headed “Sustainability”). And it is one to which we have given a very great deal of thought elsewhere, notably in relation to the sustainability of cities and, in particular, in respect of determining what should be decided by way of policy for “tomorrow” (the immediate future) without foreclosing on the eventual attainability of any of the community’s plural aspirations for the distant future (Beck 2011).

2.1 Mapping the moral positions: the contested terrain

Throughout the 1950s and 1960s the provision of housing in London was almost totally in the hands of the planners: far-sighted experts who were convinced that, for the common good, the development of the built environment should be brought under control and firmly steered in the desired direction. One of their main concerns, therefore, was the renewal of the war-torn and worn-out fabric of the inner city. One of their number, Harold P. Clunn, put it like this:

“London ... is marching on to a destiny which will make it the grandest city in the whole world ... London must be allowed to grow upwards and the straggling villas and small houses of Highbury, Barnsbury, Stoke Newington, Hackney, Maida Vale and St John’s Wood must give way to new blocks of flats” (Clunn, undated: 26-27).

In material terms, Clunn is talking about a good half of London’s fabric: all that part, beyond the old cities of London and Westminster, that was built by the Georgians and the Victorians. It is roughly the equivalent, in Vienna, of demolishing and re-building everything between the Ringstrasse and the Gürtel. In New York, it would not be far short of the whole of Manhattan, together with outlying places such as Brooklyn Heights.

Much of this vast swathe of London did indeed give way to new blocks of flats and, if the planners had had it all their own way, and if enough money had been made available to them, their algorithms for determining just when a section of the built environment had become “optimally demolishable” (their terminology) would have ensured that every urban acre underwent its “comprehensive redevelopment” (again, their terminology). Fortunately, a creative and motley alliance of owner-occupiers and grassroots activists (the Victorian Society, for instance, and the association that sprang up to fight the demolition of Islington’s Packington Square) who saw these 18th and 19th century houses as sadly-neglected heritage not rat-infested slums (the official perception, as voiced by the then housing minister, Richard Crossman), were able, through their myriad and often uncoordinated efforts, to derail the planners’ singular and unrelenting vision of the New Jerusalem⁷. It was this anarchic and innovative bunch who, in effect, privatised the despised communal burden, *re-valued* it (just one of those “straggling villas and small houses” – those around Arsenal’s old stadium among them – could now set you back several millions of pounds) and put it into the healthy and highly liveable state in which we now see it (see Box B: The Two Destinations: The Rubbish Dump and the Museum). This re-valuing of the built environment is something that now continues apace in almost every European and North American city (and even in less occidental places, such as Kathmandu), but it would never have happened if control had remained in the hands of the planners.

⁷ *The Sack of Bath – And After* (Fergusson and Mowl 1989) chronicles what was perhaps the most spectacular instance of this sort of derailment.

If today's material flows are indeed unsustainable just think what they would be like if the planners had had their way! And, since it is those “anarchic and innovative privatisers” – the villains of the piece in the conventional orthodoxy about the unsustainability of our material flows – who we have to thank for averting that horrendous future, we should pause to examine how they did it. *They* were the actors who invented the re-valuing of the built environment. *They* were the ones who put a stop to the total physical renewal of the city every 50 years or so. It was *their* undermining of the planners' “vision of the future” that resulted in all the “social learning” that we are the beneficiaries of today. In other words, if they have managed to move things *so far* in the material flow-lessening direction that is seen as so desirable by those who espouse the conventional orthodoxy, then we should seek to build on those achievements if we wish to go even further: all the way, we will be arguing, to the point where we are living in cities that are “walking on air” (Beck 2011; 2014a). This realisation has some important consequences.

- Those parts of London's inner suburbs that were comprehensively redeveloped resulted in massive material flows. The bricks and mortar from those optimally demolished buildings were all carted away to be dumped in land-fills or used as hardcore, and all the timber – flooring, joists, staircases, rafters, doors, etc. – was burnt on-site. Many of the replacements – high-rise systems-built tower blocks, in particular – have proved disastrous, structurally, socially or both, and have had to be demolished long before their planned 60-year life has elapsed (indeed, one of them – Ronan Point in the Borough of Newham – demolished itself, less than a year into its allotted span).
- These colossal flows dwindle to a trickle in the case of those parts that have been re-valued. The bricks, the mortar, the timber, the slates and the cast-iron balconies are still in place; they have not flowed anywhere. Of course, there has been work, and there will have to be much more if those houses are to stay in existence forever, which is the present intention (see again Box B: The Two Destinations: The Rubbish Dump and the Museum).
- But the flows that are generated by the careful and continuous repair of a renewable resource (which is what this swathe of London has now become) are altogether different from those that are generated by comprehensive redevelopment. Now, when a part of a building *is* demolished, every brick is saved, even half-bricks (which form what look like “headers” in the modern cavity wall construction method, in which the outer brick skin is tied, using alloy links, to an inner blockwork skin). Even more so with fireplaces, handrails, cast-iron fittings, door furniture and so on, all of which are profitably re-cycled by way of small local businesses that specialise in what is called *architectural salvage*.
- The building work itself is much more skilled, and it is labour-intensive (not material-intensive and machine-intensive, as is comprehensive re-development). It is also much more local and small-scale: good builders being passed on, by word-of-mouth, from house to house, often without even a change of street.
- Along with the growth of architectural salvage, there has been an astonishing re-birth of skills that had virtually disappeared by the 1960s: ornamental plastering, bespoke kitchen-making, traditional joinery, scagliola, stained glass, the laying of tessellated floors ... on and on. There is nothing that originally went into these houses that is not now being produced or done.
- And, to help people actually do it all, there is now a whole communication industry – from museum curators and academics to glossy magazines (like *Period Living* and

Traditional Homes), coffee-table books and television programmes – all merrily coining it in and spreading the word.

- Nor would it be right to see all this as “retro” or neo-Luddite. New technologies – timber-treatments, damp-proofing, forced ventilation, “Velux” roof windows, the aforementioned cavity wall construction methods, and so on – are key ingredients in this process that has been set in train by re-valuation. This inner swathe of London, moreover, probably contains the highest proportion of “home-workers” anywhere in Britain (especially now that the re-valuing of former warehouses and factories has provided all those “work-live” units). Indeed, these homes/workplaces fairly hum with the latest information technology. For instance, the 18th century silk-weavers’ houses in Spitalfields (the until recently run-down district immediately adjoining the City of London) have become the electronic cottages of the 21st century, providing an impressive response to one of the great challenges of the new millennium: *designing for selective slowness*. Until recently, getting anything to go faster was automatically better, but, with the transition to the “post-industrial city”, this is no longer the case, and these houses and their inhabitants now combine very high-speed and high-volume technologies of information with impressively slowed-down material flows (the “slow food movement”, for instance, and a very low level of car-ownership). Far from having “turned their backs on the future” or “pulled the plug on progress” (which is the prevailing perception; see Katz 1996) these dwellings-cum-inhabitants *are* the future!

Box B: The two destinations: the rubbish dump and the museum

How, some may demand to know, can things like houses last forever? To answer this we have to turn to *rubbish theory* (Thompson 1979; 2003). First, however, it is important to note that it is the *intention* that they should last forever; actually getting that to happen is another matter (we feel a sense of loss on learning that Lady Churchill burnt Graham Sutherland’s portrait of her husband – “the greatest living Englishman painted by the greatest living English artist” – but nothing comparable when we chuck a pair of old shoes in the bin).

The explanation, of course, is that possessable objects can fall into one or other of two cultural categories: the *transient* (in which items steadily decline in value and have finite expected life-spans) and the *durable* (in which items steadily increase in value and have infinite expected life-spans). Most objects start off in the transient category, and it is only later that some of them are transformed to durability, and this raises the question of how this transfer is possible, given the mutual incompatibility of the criteria that define these two categories. The answer is that the direct transfer is not possible, but that there is a third and covert category – *rubbish* – and that this provides the crucial pathway (Figure B.1).

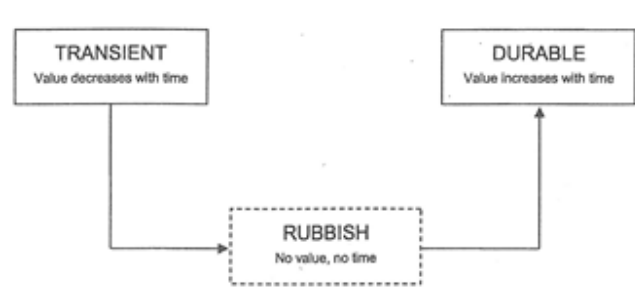


Figure B.1: Cultural categories of objects and the possible transfer between them

A transient object, decreasing in value with time and use, eventually sinks into rubbish: a timeless and valueless limbo. In an ideal world (a world uncannily close to that assumed by neoclassical economics; see Thompson 2010) it would then disappear in a small cloud of dust, but often this does not happen and it lingers on, unnoticed and unloved, until perhaps one day it is discovered by some creative and upwardly mobile individual and successfully transferred to the durable category. This is how something second-hand becomes an antique and how, as has happened with many a run-down inner city district, a rat-infested slum becomes part of Our Glorious Heritage. Hence, as Michael Fehr (2005) discerned, the two possible destinations: the rubbish dump and the museum.

- There is a *system* at work here, with its own dynamics linking intangible cultural categories and real physical arrangements (houses among them). It is, for instance, thanks to these dynamics that most museums nowadays are able to exhibit just one or two percent of the objects they own.
- Transience, rubbish and durability are crucial components in this system, yet there is nothing in the physical properties of the objects themselves (houses among them) that will tell you which category they belong to.
- Those who ride the downward flow (transience to rubbish) are not at all the same “social actors” as those who ride the upward flow (rubbish to durability). For instance, the house in Islington (see Figure B.2) that, back in 1970, had its brickwork painted pink with the mortar picked out in white was owned and lived in by a Greek Cypriot family that had recently arrived in Britain. That same house, in 2003 (having somehow escaped its optimal demolition) had had its brickwork cleaned at considerable expense, along with other extensive restoration works, and was lived in by a field-marshal and his family.



Figure B.2: The flows and their riders

- Intervening in such a system so as to steer it in some desired direction – sustainable development, for instance – is not easy, especially if you have no understanding of what the system is. (One recent proposed intervention – it originated in Oxford University’s Environmental Change Unit and outdid even Mr Clunn’s vision of the future – was that all houses built before the advent, in the 1920s, of cavity wall construction methods be demolished and replaced with more energy-efficient dwellings).

So the good news is that we used to be committed to physically turning over our built environment every 50 or so years and now we are not. And it is the market and egalitarian actors – the owner-occupiers and the grassroots activists – that we have to thank for that, not the hierarchical actors. Re-valuation, we should note, is altogether different from re-cycling. In re-cycling, the building itself disappears and its physical components are then re-used in the construction of a new building (or, more likely, buildings). Re-valuation, however, is something that happens in our heads, and the building itself stays in place. The only change, to begin with, is in our attitude to the building. But, once we see it as sadly-neglected Glorious Heritage, rather than awful rat-infested slum, our behaviour towards it changes and that (as we have just seen) leads to all sorts of changes in the material flows associated with the city of which it is part.

So we now have the map of moral positions: the hierarchical institutions (Mr Clunn and his ilk) with their “New Jerusalem”, the egalitarian institutions (the proponents of that limits-respecting orthodoxy) with their insistence that we need “a whole new relationship with nature”, and the individualist institutions (the market-oriented owner-occupiers) with their noses atwilt at the prospect of re-valuation. Individualistic actors, being (in Mary Douglas’s felicitous term) “pragmatic materialists”, might seem to be the odd ones out here, but there is a moral position around which those who believe in a life of bidding and bargaining are gathered. This is the Adam Smithian argument that the pursuit of self-interest pays off only when it adds to the welfare of the totality: “the hidden hand” (for the map itself, and its various predictions, see Box C: A Complete Map of Moral Positions). With this map, we can now resist the almost overwhelming urge to pronounce just one of these positions right and the others wrong, thereby moving ourselves away from the various elegant solutions and towards clumsiness. Put another way, there is some vital mutuality here, despite the irreconcilable differences between the three moral positions. To speak of one or other of them as “winning”, which is what you do if you opt for elegance, is therefore as nonsensical as saying that the lions of Serengeti have won when they’ve eaten the last wildebeest in the park!

Box C: A complete map of moral positions

For many purposes – understanding what was going on with Arsenal’s new stadium, for instance, or with the re-valuation of London’s inner suburbs – a rudimentary and triangular map will suffice (Figure C.1).

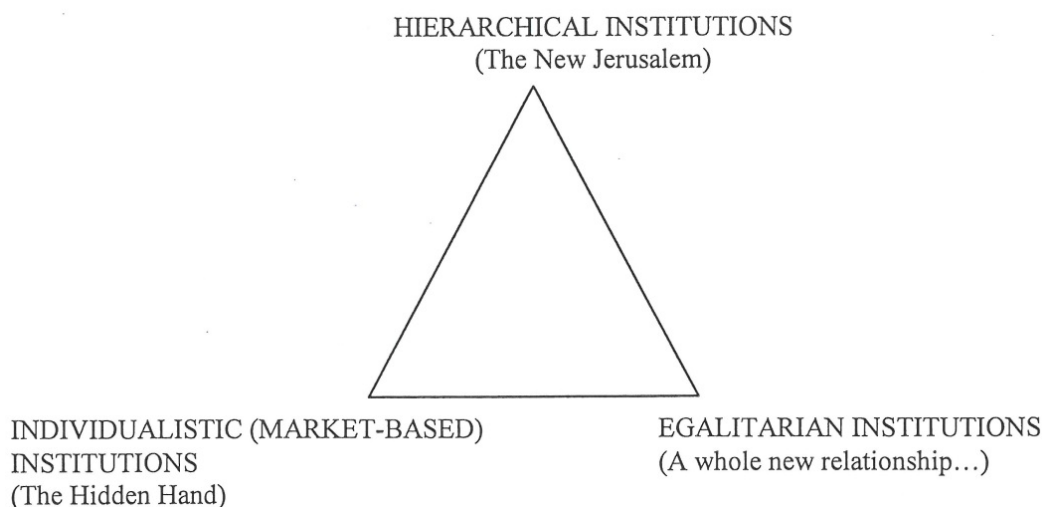


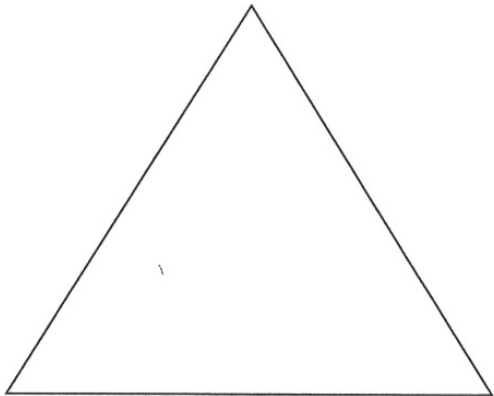
Figure C.1: A rudimentary and triangular map

For other purposes, however, a more detailed, but still triangular map is needed. Figure C.2 is an example of such a map, it having been drawn specifically for that wicked problem, climate change.

Often, however, we are not justified in leaving out the fourth solidarity: the fatalist way of organising. Marco Verweij, for instance, needed a rectangular map for his case studies of elegant failures (Verweij 2011), one of which – the Rwanda genocide – involved the drowning out of the individualist, hierarchist and egalitarian voices by the fatalist one. He also wanted to do something about the two well-known weaknesses of the case study method: that it is difficult to ensure their valid comparability and that it is difficult to get enough of them to ensure a statistically significant sample. To that end, he selected, from the 60-odd sets of predictions from the theory of plural rationality that have been compiled (most notably by Patrick Hofstetter 1998), the thirteen that he reckoned to be the best. He then used these in all four of his case studies, the idea being that if other researchers followed this lead a significant number of comparable case studies would quickly accumulate (Figure C.3).

Hierarchical institutions

- Myth of nature: perverse/tolerant
- Diagnosis of cause: population
- Policy bias: contractarian
- Distribution: proportionality
- Consent: hypothetical
- Liability: deep pocket
- Intergeneration responsibility: present > future
- Discounting: technical standard



Market institutions

- Myth of nature: benign
- Diagnosis of cause: pricing
- Policy bias: libertarian
- Distribution: priority
- Consent: revealed
- Liability: loss spreading
- Intergeneration responsibility: present > future
- Discounting: diverse/high

Egalitarian institutions

- Myth of nature: ephemeral
- Diagnosis of cause: profligacy
- Policy bias: egalitarian
- Distribution: parity
- Consent: explicit
- Liability: strict fault
- Intergeneration responsibility: future > present
- Discounting: zero/negative

Figure C.2: A more detailed triangular map (for an explanation of the various headings – “myth of nature”, “diagnosis of cause”, etc. – see Thompson and Rayner 1998).

So these maps, be they rudimentary or detailed, triangular or rectangular, are rough-and-ready tools that can be picked up for different practical purposes.

Ultimately, all these maps derive from those 60-odd sets of predictions from the theory (to which, of course, more are being added all the time). The “requisite detail”, in any particular instance, is that which will enable us to identify the various voices: those that can be clearly heard *and* those that are missing. Put another way, the maps are policy tools for the analysis of contending discourses. And discourse, contra the single rationality logic that is enshrined in those four precepts of policy analysis, is what DMUCC is all about!

	Individualism	Egalitarianism	Hierarchy	Fatalism
View of human nature	Intelligent and informed, but egocentric and materialistic.	Essentially altruistic and caring, but corruptible by money, status, and power	Sinful without imposed guidance and restraints, as well as highly differentiated in terms of morals and intelligence.	Unpredictable, deceitful, and amoral.
View of nature	Cornucopian, abundant.	Ephemeral, fragile.	Stable within boundaries that are knowable to experts.	Unknowable.
Domestic governance ideal	Night-watch state and pluralist (Madisonian) democracy with checks and balances to maximise individual freedom.	Withering of the state to make place for small, autonomous groups practicing participatory democracy.	Wise, benevolent, top-down state planning; if democracy, then indirect (Burkean or consociational) democracy.	Personal rule (fiefdom); at best benevolent dictator.
International governance ideal	The spread of unfettered, global markets and Madisonian democracy.	Global solidarity between small, autonomous political units; if not yet feasible, then rule by global civil society.	Extensive international and supranational institutions and treaties (if not world government).	Short-term alliances to maintain balance of power; or a (hopefully) benevolent hegemony of one state.
How to organise the state of intergovernmental bodies	As a competitive market (with material incentives for competing agencies and civil servants).	As a collegium.	As a bureaucracy.	Chaotically, and on personal, secretive lines, through corruption and nepotism.
Economic ideal	Unfettered, competitive markets.	Local production and consumption, collectively decided upon.	Centrally planned production, allocation, and consumption.	Getting rich at the expense of others (mercantilism; kleptocracy).
Preferred leadership style	Bold, decisive (leading from the front)	Charismatic (leading by example).	Procedural (leading according to the rules).	Machiavellian (unpredictable, secretive, ruthless, cunning).
Blame	Individual responsibility (and any imposed restrictions on individual autonomy).	The inequitable system (and those it empowered).	Those who did not follow instructions.	Others (scapegoating); fate; and one’s own gullibility.
Attitude towards economic, technological and environmental risks	Risk is opportunity.	Risk needs to be minimized.	Risk needs to be managed.	Risk is endemic and cannot be eradicated; therefore, it needs to be shed unto others.
Perception of time	Short-term (live for the day).	Compressed (now is the most important point in time in all history).	Stratified and long-term.	Undifferentiated; same old, same old (nothing ever changes; time has stopped).
Knowledge	Uncertain, temporary and only discoverable through continuing trial-and-error.	Imperfect and holistic (everything is intimately connected to everything else in hard-to-comprehend but vital ways).	Objective and permanent (when generated by the appropriate authorities).	Secretive and deceptive.
Preferred technology	Whatever proves most efficient (and profitable).	Locally constructed, small-scale and simple (requiring little investment or expertise).	Capital- and knowledge-intensive (complicated and large-scale).	Whatever gives an edge over rivals.
Justice	Equality of opportunity.	Equality of condition.	Those at the top aiding those at the bottom.	Whatever is necessary for survival (amoralism); if I don’t do it, somebody else will.

Figure C.3: An even more detailed, and rectangular map

And it is this mutuality that is responsible for the counter-intuitive, and highly constructive, property of clumsy solutions: their giving those who are gathered around each of the moral positions more of what they want (and less of what they don't want) than they would have got if they had managed to impose their own elegant solution – just as in the case of the Arsenal football stadium.

- The *hierarchical* planners, in clinging to comprehensive re-development, were losing control (and control, above all else, is what they want). However, they were able to regain control, once the individualist and egalitarian actors had de-railed their comprehensive development, by designating the re-valued streets and squares as “conservation areas” and by statutorily listing the individual houses as being “of outstanding historical or architectural interest”.
- The *individualistic* owner-occupiers, though they resented the loss of personal freedom that accompanied these hierarchical interventions, have found that being in a conservation area, or being “listed”, adds considerably to the market value of their houses. This, in turn, enhances the tax-base of the local government authorities, enabling them, among other things, to enforce the various planning controls in the conservation areas and in relation to the listed buildings. Individualistic and hierarchical actors, thus, each give up something but gain much more: a bigger “bottom line” for the former, and a re-gaining of control for the latter.
- *Egalitarian* actors, though they may not have succeeded in equalising all social differences, have certainly secured a common-pool good (as evidenced by their battle-cry “Reclaim the streets”) where previously there had been only private goods (individualism), public goods (hierarchy) and club goods (collusion – “crony capitalism”, as it is called – between individualism and hierarchy). They also have the satisfaction of knowing that, at the present rate at which the built environment is being replaced, each dwelling will last longer than the Pyramids: about as spectacular a reduction in material flows as one can imagine (and getting us all to “tread lightly on the Earth”, as we have seen, is their prime moral concern).

A final double-point is that, while we have been looking at material flows within a major developed-world city – a city that has accumulated all kinds of *path dependency*, thanks to it having been central to the Industrial Revolution – material flows do not stop where the green-belt starts (Villarroel Walker and Beck 2012; Billen et al 2012; Kim and Barles 2012). Nor do cities that did not experience the Industrial Revolution display the sort of *technological lock-ins* that are more or less taken for granted in London. So, in order to remedy those omissions, we will now turn to our second case study: material flows between the city and its hinterland in a least-developed country, Nepal.

3. Near-destitute Maoist insurgents transformed into increasingly prosperous market gardeners

Every morning, high on the mountainous rim of Nepal's Kathmandu Valley, a second-hand Austrian cable system moves metal carriers containing fresh milk across a deep valley to a truck waiting on the nearest road. Given the rugged topography, this two-mile link is a simple, cheap, and efficient way of getting milk to market in the capital city before it spoils. When one of us (MT) first came across the cable system – it is called the Bhattedanda Milkway – it was just a curiosity: an interesting solution to a problem of a kind that, given the country's remarkably crumpled terrain, is always cropping up. But, when he learnt of its long and conflict-ridden history, he realised that it provided an excellent illustration of his and others' work on the *theory of plural rationality*. This theory – which, of course, underlies our “wicked problems, uncomfortable knowledge, clumsy solutions” framing – holds that there are just four solidarities: four ways of organising, perceiving and justifying social relations: hierarchy, individualism, egalitarianism and fatalism.

These four “ways of life” conflict in every conceivable social domain, because each will define both the problem and the solution in a way that contradicts the others, hence the vital significance of DMUCC. There are, in consequence, four “voices”.

- The hierarchist voice is pro-control. It talks of “global stewardship”, is quick to point out that what is rational for the parts may be disastrous for the whole, and insists that global problems (such as climate change) demand global and expertly planned solutions.
- The individualist voice is pro-market. It calls for de-regulation, for the freedom to innovate and take risks, and for the internalisation of environmental costs so as to “get the prices right”. Do these things, these actors insist, and the “hidden hand” will ensure that everyone is better off.
- The egalitarian voice is strident and critical. It scorns the idea of “trickle down”, focusing, instead, on “the poorest of the poor”. It argues for zero-growth and calls for major shifts in our behaviour so as to bring our profligate consumption down within the limits set by Mother Nature.
- Fatalist actors see no possibility of effecting change for the better, and (like Arsenal's “cannon fodder” supporters) tend to have no voice. Even so, they have their vital part to play because we need to hear their counsel so as to not waste time and money over things about which we can do nothing.

Development aid – from its very start, in the immediate aftermath of the Bretton Woods Conference at the end of World War Two – has been framed largely from just the hierarchical standpoint (which, as we will see, is something it shares with sustainable development). In consequence, it has always been elegant: imposing just one of the four sets of contradictory certainties and marginalising the rest. But no hegemony can last forever and, just as London's planners were undermined by all those owner-occupiers and egalitarian activists back in the 1960s, so the excluded voices on Bhattedanda (*dandas* are high, rounded and often quite densely populated ridges) were eventually

able to force their way in.⁸ The result, as we will see, has been as transformative, and as constructive, as was the case with London's inner suburbs (and with Arsenal's new stadium). What is more, these transformations have been effected in the midst of a 10-year "people's war" (1996-2006), waged by Maoist insurgents, many of whom originated on Bhattedanda (and on other neighbouring *dandas*). Indeed, it can be argued that this murderous insurgency, which left somewhere between 14,000 and 16,000 people dead, was the direct consequence of all those decades of excessively elegant development aid.⁹

3.1 Escape from elegance

Kathmandu, like so many cities in South Asia (and in marked contrast to the "mature" cities in Europe and North America) is growing uncontrollably: more rapidly, in fact, than did Manchester in the heyday of the Industrial Revolution. Indeed, in just the decade of the "people's war" the population mushroomed from 300 thousand to 3 million. With the highly productive land in the valley itself, which for centuries had provided most of Kathmandu's food, now largely covered in buildings, the sky-rocketing demand (especially for perishables, such as milk and fresh vegetables) has reached out to, and beyond, the valley's rim. In consequence, the villagers on Bhattedanda have found themselves sucked into a system of flows that is both new and ever-changing. On top of all that, for much of that time, insurgents from that periphery have been laying siege to the city itself and thereby playing havoc with those flows. How, then, have the villagers and the city-dwellers coped with these changes? Remarkably well, is the answer, but not in the way hierarchical actors had envisaged!

The villagers, before the milkway was built, had no option but to boil their milk down into *khuwa*: a longer-lasting but less valuable condensed form. With the advent of the milkway, the five-hour trek carrying the *khuwa* down into the ravine and then up to the road on the other side has been reduced to a 20-minute, and drudgery-free, transport. The economic benefits, once the ropeway opened in 1995, were immediate, with villagers' incomes increasing by at least 30 per cent. But other effects have proved to be equally important.

- The villagers no longer had to spend hours each day collecting firewood or sitting in front of a hearth boiling milk. "Household members", Madhukar Upadhyaya, the author of the Bhattedanda case study, writes, "especially the women and children, had to inhale the smoke while *khuwa* was being made. Now the indoor air is much cleaner".¹⁰
- Once *khuwa* processing stopped, so did the cutting of the 400 tons per year of firewood needed to boil down the milk. With young plants and saplings no longer being trampled by firewood collectors, the health of the forest is much improved and biodiversity loss has been reversed.¹¹

⁸ The opportunity came, it has been argued (Gyawali et al 2015), with the end of the Age of Aid, that being brought about by the collapse in 1989 of the Soviet Union and, with it, the end of the Cold War (throughout which the two superpowers had competed for influence by lavishing aid on those undeveloped countries that had constituted "the rest" in the Bretton Woods settlement).

⁹ The Maoists were able to take control of some of the more remote districts. They then initiated a rough-and-ready assessment of the on-going development projects. Those (mostly NGO-led) that they judged to be benefitting the poorest of the poor they left alone; indeed actively supported. The others they destroyed.

¹⁰ The Bhattedanda Milkway is one of eight case studies in the book *The Toad Beneath the Harrow: Nepal's Experience of Foreign Aid* (Gyawali et al 2015 forthcoming).

¹¹ Biodiversity being one of the "planetary boundaries" that, it is argued (Rockström et al 2009), will have to be respected if we are to become sustainable.

- In addition, Upadhyaya notes, “farmers realised that they could export perishable farm produce to market ... and have now diversified into tomatoes, green vegetables, and beans.” And with increased income has come better healthcare, schooling for the village children, and corrugated iron rather than thatched roofs on their houses.
- Finally, thanks to the increased revenue, the village milkway committee is now able to provide loans to local merchants and farmers at interest rates far below those charged by the banks and the moneylenders. “The ropeway,” Upadhyaya writes, “has thus become not only a transport system but a community-wide benefit provider, thanks to the social capital it has itself generated.” As obvious as these benefits may seem, constructing, maintaining, and managing the milkway was not a straightforward process.

In 1985, when the Nepali government, with the European Union as the aid donor, initiated a “watershed project” in the area to lessen the likelihood of landslides and floods, poverty-alleviation was not on the agenda. Five years later, the Nepal Water Conservation Foundation, as part of an assessment of the project, raised the question of what kind of aid could actually help the local people. Only then, when it emerged that the cycle of poverty was tied to the making of *khuwa*, was a diesel-powered ropeway proposed. The idea was not well received.

The ropeway, officials objected, was not part of the authorised watershed project and would be more expensive than planting trees and stabilising landslides. Beyond that, there was no local expertise to build and operate a ropeway, the Ministry of Forests did not fund transportation projects, and community mobilisation was irrelevant because, as Upadhyaya notes, the whole ropeway idea was “unheard of”. The objections, it hardly needs saying, reflected the hierarchical view; the individualist and egalitarian voices were silenced (and the uncomfortable knowledge that they carried dismissed as “unheard of”). But in 1990, as democracy was restored and a 30-year ban on political parties lifted, the Nepali government and its foreign donors were no longer able to set the development agenda. With other voices able to make themselves heard in the new political context, the ropeway suddenly gained favour and began operating in 1995.

Its rapid economic success raised new concerns. Some worried that funding for road construction would be reduced, and political leaders who had not been involved in the project, and thus could not take the credit for it, began to push for the reinstatement of an old and unusable road as a better alternative. On Bhattedanda itself, squabbles within the milkway management committee eroded its democratic basis and, once the road was repaired, the cable system was shut down. Hierarchy held sway once more.

A few years later, heavy rains washed away the new road and the export of fresh milk came to an abrupt halt. The villagers were suddenly back in their cycle of poverty, boiling down milk into *khuwa*. They responded by resolving their political differences, reopening the milkway and setting up a new management system. In the process, they converted the power source from imported diesel to local hydroelectricity, making the operation more environmentally friendly and much cheaper.

3.2 Who benefits?

In the midst of all this seemingly unsustainable change, the Bhattedanda Milkway provides a salutary demonstration of what can be achieved through clumsiness. As with those re-valued houses in London, and with Arsenal’s new stadium, each set of actors ends up getting more of what it wants, and less of what it doesn’t want, than it would

have received if it had managed to silence the others and impose its own elegant solution.

- However you choose to measure it, the milkway is economic growth – development as defined in the conventional “aid paradigm” – achieved, moreover, by means of a carefully planned intervention that would never have happened “autonomously”. So those speaking with the hierarchical voice have certainly achieved much of what they wanted.
- Individualist actors – the farmers, with their incomes immediately increased by 30 per cent or more – have also come out well, especially when you take into account the host of innovations that have shifted them away from a precarious subsistence agriculture into what is an increasingly lucrative form of market gardening.
- And those who speak with the egalitarian voice have secured the conservation of the forest, along with a convincing demonstration of how to effect the transition from fossil fuels to renewables. Moreover, it is the “poorest of the poor” who have benefitted most. Even more so, now that the ropeway has been extended to the next *danda*: a *danda* so remote and so impoverished that hitherto could not even get its *khuwa* to market. Indeed, it used to be said of it that all it was good for was producing Maoist insurgents.

4. What does this framing, and these examples, tell us about urban resilience, sustainability, adaptability and path dependence (and how does that differ from current understandings)?

First, this framing and these examples tell us that *rationality is plural*: fourfold, in fact. For instance, those (the hierarchical actors) who see nature as stable-within-discoverable-limits will likely behave very differently from those (the egalitarian actors) who see nature as everywhere precarious. In other words, they will tend to adopt different strategies and to provide very different justifications for the behaviour (and the policy preferences) that those strategies give rise to. Second, they tell us *not to trust the precepts of policy analysis*, which (to re-iterate) are: (1) ensure a single agreed definition of the problem, (2) be careful to distinguish facts from values (as in Daniel Patrick Moynihan's "Everyone is entitled to their own opinions but not to their own facts"), (3) set up a single metric (dollars, lives saved, etc) so as to be able to assess and compare options and (4) optimise around the best of those options. Those elegance-imposing precepts, we have argued, are valid only for tame problems and, when it comes to cities and their governance, there are precious few of those around. Almost all the problems are wicked problems and therefore require clumsy solutions. Since both single rationality (sometimes, as we have seen, doubled-up to markets and hierarchies) and those four precepts (the pre-requisites, we have argued, for DMUU) are much relied on in current thinking about urban resilience, sustainability and adaptability, and since path dependence (and its accompanying technological lock-in) is not countenanced within that conventional approach, there is much that needs to be carefully re-assessed.¹²

4.1 Sustainability

As we have already argued, sustainability is an essentially contested notion (Thompson 2011; Beck 2011). Since it can never be pinned down in a single way, it needs always to be clarified through discourse, and the pre-requisite for that is the access and responsiveness of those who speak with the different voices: individualistic, hierarchical and so on. And the theory of plural rationality holds that, while the doubling up to markets-and-hierarchies is a step in the right direction, it still excludes two of the voices that need to be heard and responded to. The theory therefore posits the afore-mentioned four ways of organising – individualism, hierarchy, egalitarianism and fatalism – each of which is, at the same time, a way of disorganising the other three. Together they constitute a complex and disequilibrating dynamical system, within which their fortunes continually wax and wane, but without any of them going into permanent extinction. Moreover, the decisions they variously take transform the environment within which they are acting, propelling it through a never-ending but erratic sequence of "risk seasons". The whole, therefore, is what is sometimes called an *epigenetic landscape* (Waddington 1957).

¹² A bold claim, we concede, but well-supported, particularly by way of the eight case studies in Verweij and Thompson (2011).

This “anthropological approach” has now been extensively applied to risk in general, and to financial risk in particular, and it is our hope that it will also shed some helpful light on the city and our involvements with it (Beck et al 2011; 2013; Ingram et al 2012). To that end, we will now quickly explain the theory by way of the different forms of knowledge that sustain each of these ways of organising and, in so doing, become so uncomfortable to those who are organising in the other three ways (Figure 1).

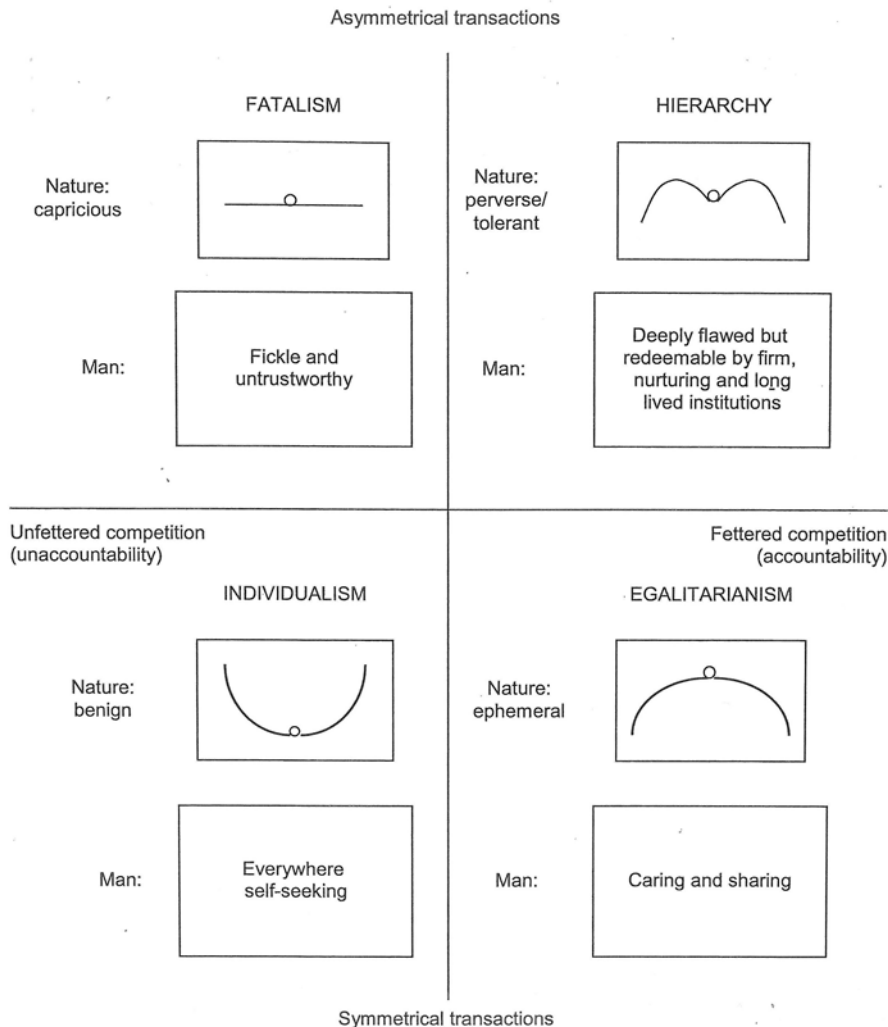


Figure 1: The four ways of organising and their associated myths of nature

Though this may appear to be a rather daunting diagram, much of what it contains is fairly orthodox. Indeed two of the ways of organising (as we have already observed) have long been familiar to institutional theorists; they are usually referred to as markets and hierarchies (Williamson 1975; Lindblom 1977), with their somewhat tangled roots reaching back to the dualistic distinctions of the masters: Maine’s (1861) *status* and *contract*, Tönnies’ (1887) *Gesellschaft* and *Gemeinschaft* and Durkheim’s (1893) *organic solidarity* and *mechanical solidarity*. The theory’s novelty therefore lies in its addition of the other two ways of organising, and in its making explicit the different myths of nature (or social constructions, or contradictory certainties) that sustain these four fundamental arrangements for the promotion of social transactions. Nor are these four fundamental arrangements entirely unfamiliar, since they map onto the four kinds of goods – *private*

(individualism), *public* (hierarchy), *common-pool* (egalitarian) and *club* (fatalism)¹³ – that have long been recognised by both economists and political scientists (e.g. Samuelson 1948; Snidal 1991).

- Hierarchies are founded on formal status distinctions and inculcate deference. In consequence, upholders tend to place their trust in expert, certified knowledge (Royal Societies, for instance, and Intergovernmental Panels) and to subscribe to a view of nature that is forgiving of many interventions but is vulnerable to those excessive perturbations that may carry the totality beyond its stabilising limits. Hence the icon (top-right in Fig. 1) of a ball nestled in a valley between two peaks. Hierarchical actors also tend to a view of human nature as originated in sin but redeemable by firm, long-lasting and nurturing institutions (as in the head-masterly “Give me the boy and I will give you the man”). Steering a carefully controlled path between stability and instability, hierarchical actors are committed to wise guidance and far-sighted stewardship. Everything therefore hinges on their discovering just where the limits are and then ensuring (by statutory regulation, for instance) that everyone stays on the right side of them. Whenever we hear talk of “safe limits”, “assimilative capacities”, “tolerable risks”, “dangerous climate change” and so on – and we hear such talk in both local and global forums – we are in the presence of hierarchy.
- Individualist actors, however, do not talk like this. They see nature as robust enough to bounce back from anything we throw at it (hence the ball-in-a-basin icon in Fig. 1, bottom left) and they consider man to be inherently competitive and self-seeking. They therefore put their trust in those institutional arrangements – the sort of ego-focused networks that characterise markets – that harness man’s self-seeking nature to the benefit of all. Adam Smith’s “hidden hand”, these actors feel, is all the guidance they need, and they note that its track-record in terms of wealth-creation and technological innovation has not yet been brought to a halt by any natural limit. “If something is unsustainable”, they assure one another, “it will stop!” In consequence, and unlike the hierarchical actors, they are not too fussy about the provenance of their knowledge. What matters to them is that it works (preferably before it works for their competitors; hence their keen interest in “intellectual property rights”). What does cause them concern, however, is when the hierarchical and egalitarian actors use their knowledges to justify placing restrictions (via statutory regulation and the precautionary principle, respectively) on the individualistic urge to engage in trial-and-error. This exuberant and anarchic interrogation of Mother Nature is justified by the “mean-reverting” assurance that is provided by the ball-in-a-basin icon, and is in marked contrast to both the “wise guidance” that upholds the hierarchical way of organising and the injunction to “tread lightly on the Earth” that supports the egalitarian way.
- Unsurprisingly, therefore, egalitarian actors are aghast at this “business-as-usual” complacency. They see nature as everywhere precarious (hence the ball on the up-turned basin icon in Fig. 1, bottom right) and, joining with Rousseau, they see man as essentially caring-and-sharing (until corrupted by those inequity-generating institutions: markets and hierarchies). Critical and uncompromising, they are not prepared to stop off at the hierarchical half-way house. Nature, they are convinced, allows us no safe limits, and they are deeply distrustful of the sort of “bench science”

¹³ To be precise, it is the ease with which the upholders of the fatalistic way of organising can be excluded that makes club goods possible.

that is so relied on by hierarchical actors. Holism – the insistence that “you can never change just one thing” (which, of course, is what those bench scientists claim to do) – is the bedrock of egalitarian science.

- Finally, fatalism (which we have rather neglected up till now) is the odd one out. This is because, unlike with the other three, its rules are made by those who are not themselves the upholders of this way of organising. Fatalism is a sort of passive margin that is made up of those who find themselves squeezed out from the three “active” ways: unable (like the “undeserving poor”) to conform to the expectations of the hierarchy, unable to come up with the entry fee for the market, and unable to muster the communal fervour that keeps the upholders of egalitarianism equal and united. Nature, they know, operates without rhyme or reason, and man is inherently fickle and untrustworthy. With no way of getting in sync with nature – push the ball this way or that and the feedback is everywhere the same (the “flatland” icon in Fig. 1, top-left) – or of building trust with others, the fatalist world (unlike the other three) is one in which learning is impossible. “Don’t just do something, stand there” is therefore the sensible advice. Even so, there *is* some experience and wisdom in this. It reminds us that time and money spent on something about which nothing can be done is time and money wasted. Moreover, recent research into the behaviour of insurance companies during the five or so years, post-2008, that were characterised (by Ben Bernanke, among others) as *uncertain* (neither *boom*, that is, nor *bust*, nor *moderate*) has shown that the fatalist strategy – essentially that nothing can be predicted and that diversification is the only sensible option – has considerable survival value. It was the firms that held to the individualist and hierarchist strategies that bit the dust (Ingram et al 2013). Also, this way of organising (or, rather, of being organised) alerts us to the debilitating dynamics that tend to cut-in in those over-elegant situations where one or more voices are excluded. Public-private partnerships, for instance, which back in the 1980s were seen as the panacea for the ills of the once-great American city, ended up doing away with common-pool goods – the “leaven in society”, as Denis Brion (1992) put it – and replacing them with club goods. The resulting “tacit coalition” of individualists and hierarchists (Brion even identifies the club in Philadelphia where their seedy deals were done) then left the mass of society in a position of “atomised, alienated subordination and systematic exploitation”: fatalism, that is¹⁴. All of which suggests that keeping an eye on a city’s pool of fatalism – how large is it, how stagnant is it, is it getting larger or smaller – is a worthwhile way of gauging the quality of its governance and of spotting purported cures that, because of their excessive elegance, are going to end up making things worse. In other words, the monitoring of what we could call “unwarranted fatalism” will be a handy and practical tool for getting away from elegance and into the embrace of clumsiness (indeed, the tool already exists, having been developed as a way of measuring the erosion of *social capital* (Putnam 1993)).

This sketch of the theory of plural rationality alerts us to a problem that has dogged the concept of sustainable development from the start: its non-neutrality. Sustainable development really only makes sense in relation to the hierarchical myth of nature: behaviour that lies within the stable trough between the two peaks is sustainable; behaviour that takes us beyond those peaks and onto the downward slopes is unsustainable. But, with the individualist myth of nature – the ball in a basin – *all*

¹⁴ And Hendriks (1994) has shown how a similarly tacit coalition in Birmingham resulted in the disastrously rigid Inner Ring Road, whilst Munich, which did not silence the egalitarian voice (“My door is always open” said the mayor) came up with a much more flexible road system (parts of which have now been removed or grassed over).

development is sustainable, whilst with the egalitarian myth – the ball on the up-turned basin – *no* development is sustainable. The problem is lessened, of course, once we concede that sustainable development is an essentially contested concept but, even so, there is always the risk that the elegant and singular Bruntland definition will prevail.¹⁵ Fortunately, there is at present a growing willingness to ask whether the notions of sustainable development and sustainability might not be past their “sell-by-dates” (see, for example, Beck 2014a; also a review of Taleb’s (2012) book “Antifragile”, available on-line at <http://cfgnet.org/archives/1329>).

4.2 Resilience

Unfortunately, the current top favourite to replace sustainable development – resilience – is also beset with problems. This is because the way in which it is being defined – the ability of a system to bounce back or, more scientifically, to remain within the same “basin of attraction” – is seriously at odds with the way it was originally defined (back in the 1970s, by the Canadian ecologist Crawford “Buzz” Holling): the ability of a system to cycle endlessly through a number of different basins of attraction. Indeed, the current “bounce-back” definition corresponds to what Holling, using the example of the optimised and technologically locked-in farming methods on the prairies, called *brittleness*: almost the opposite of resilience (see Box D: The Trouble With “Bounce-Back”)!

Box D: The trouble with “bounce-back”

The power and influence of Holling’s seminal ideas are evidenced, we note, in the establishment of the Stockholm Resilience Centre, 2007 (www.stockholmresilience.org).

In Holling’s conception – augmented both by his own subsequent contributions and by many others since (Holling 1973; Holling 1986; Holling 1996; Peterson et al 1998; Holling et al 2002; Thompson 2002; Salingaros 2005; Walker et al 2006; Lietaer et al 2009; Smith and Stirling 2010; and Martin and Sunley 2014) – resilience is both bounce-back and, much more so, these things:

- first, and above all, the ability of a system to cycle endlessly through a number of different and ever evolving basins of attraction, each differentiated by possibly quite different ways in which the system bounces back from disturbance;
- where (in social systems) these differentiated ways of coping in the different basins of attraction – of acting in the world (according to its current season of risk) – are determined primarily by likewise differentiated sets of beliefs about the way world works;
- with yet, in all this cycling, the system still having a recognisable structure of cohering components and providing recognisable functions deemed broadly similar, even if degraded or markedly enhanced, relative to what they were prior to (substantial) disturbance;

¹⁵ Indeed, there is a palpable yearning in some technocratic quarters for some singular, succinct and “mechanical” operational definition of sustainability. One of us (MBB), we confess, set out in pursuit of this goal in 2002. Nine years, six re-drafts, and over 160 pages of dense reasoning later, no such definition was to be found (Beck 2011).

- the capacity also – in systems with capabilities for self-observation and self-reflection – for learning and adapting, precisely because of disturbance and disorder, hence anticipating (up to a point) how to cope with future disturbance, which disturbance may (or may not) prompt change from one basin of attraction to another;
- with yet the enduring capacity to be transformed and to effect change and transformation from one basin of attraction to another, even inventing a novel basin of attraction, in ways mostly deemed for the better – continuing to develop, that is, for the greater good;
- and with this capacity for transformation itself being grounded in the (seeming) redundancies of structure and function in the system and the (in)efficiencies of those functions, all in turn determined by the strengths and weaknesses of the links among the cohering components and their duplication (or not).

It is not at all hard to sense the frustration of another nine years passing and another six re-drafts of a lengthy tome coming on. And this is exactly our point: the essence of resilience is no easier to capture than that of sustainability.

The orthodoxy, in ecology, was that there was a one-way transition, by way of “succession”, from an initially anarchic and unstructured state of affairs – the “pioneer community”, with its fast-breeding, generalised and opportunistic “r-selected species” – to an increasingly complex, orderly and ranked set-up – the “climax community”, with its slower-breeding, specialised and more energy-efficient “K-selected species”. Not so, said Holling (1986); there are two more basins of attraction: “compost” (which is what you get when the climax community, having complexified itself to the limit, undergoes sudden and total collapse) and the “collaborative fence-builders” (micro-organisms mostly that are able to colonise and fix all the now “loose” energy before it disappears down the drain, by soil-leaching, for instance). All twelve transitions between those four basins, Holling then argued, are possible, but some tend to be privileged – more likely, that is – thereby generating an endless sequence of transitions: an *ecocycle* (Figure 2).

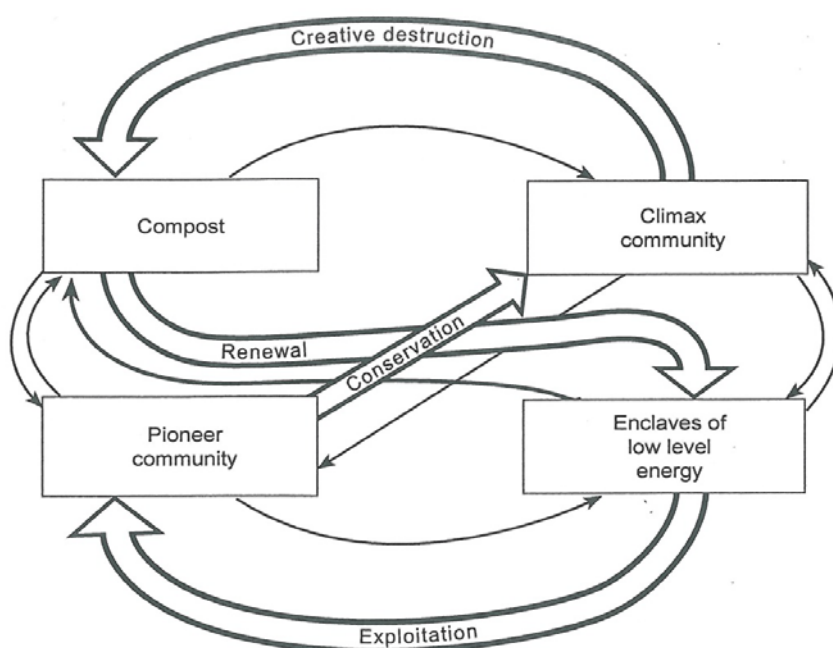


Figure 2: The ecocycle: re-drawn from Holling (1986) to be homologous with the four “basins of attraction” in Figure 1

Things went wrong, however, when people tried to take the argument from ecological/biological systems to social/economic systems, because the latter, it was incorrectly assumed, did not have multiple basins of attraction. How could they if, as rational choice theory insists, we are all the same: all self-seeking? But, with the theory of plural rationality and its four ways of organising, it is possible to propose a *socio-cycle* that exactly matches (in terms of its system properties) Holling's ecocycle. In other words, we no longer have to define social resilience in a way that is almost the opposite of ecological resilience. And in cities, of course, both cycles will be at work, in a complex (in the technical sense of the word: non-linear, unpredictable, path-dependent, etc) and constantly changing interplay. What is more, the design and operation of the built environment of the city (its infrastructure) has yet to benefit from these ideas of ecological resilience, now manifest (as they are) in the accompanying human and natural environments within and surrounding the city (Beck and Villarroel Walker 2013). Alarming though all this may appear to those who assume just one basin (or, at the most, two: markets and hierarchies), analyses based on this "man and nature as a single but complex system" framing have now been shown to make good and useful sense of what is going on in mountain villages (such as Bhattedanda in Nepal and Davos in Switzerland) and in the global financial system (Thompson 2002; Ingram et al. 2012). And if it works for those it should, we are arguing, work for cities too (see Box E: The Complex Lives of Simple Folk).

Box E: The complex lives of simple folk

Unlike in cities, where the *built environment* – all those infrastructures of roads, railways, services, sewers and so on – intervenes and mediates the relationship between *man* and *nature*, life in mountain villages is a much more direct and unmediated transactional process. An understanding of that sort of process, in village communities that have stood the test of time, should therefore reveal something of what it takes to cope successfully with change.

- In the Himalaya, villagers parcel out their transactions with the physical environment among the various ways of organising. Forests and pastures are typically managed as commons, with a local commons-managing institution assessing the carrying capacity, setting the appropriate level of use, and imposing sanctions – modest ones usually suffice – on those who transgress these stipulations (hierarchy, at a small, face-to-face social scale). Fields, domestic animals and houses, however, are privately owned, with their owners free to decide how best to exploit them (individualism). When, as happens in some areas, the village forest is under threat from external actors – logging contractors (often in cahoots with corrupt state-level forestry officials) – there is an all-in-the-same-boat response: the celebrated Chipko Movement, for instance, in which the villages mobilise as tree-huggers, *chipko* meaning "to stick" (egalitarianism). And, of course, even in villages that are brimming with "social capital", there will always be some who sneak timber from the forest when no one is looking, who never quite muster the energy to tend to their crops and livestock and sell the resulting produce, and who manage not to be around when it's all hands to the tree-hugging (fatalism).
- And we have seen much the same sort of plurality in action in the heart of London: with the de-railing of Mr Clunn's hyper-elegant vision of the future. A similarly plural interplay, Hendriks (1994) has shown, was evident in Munich, in the decades from

1945-1975, in its handling of its transport infrastructure; and markedly absent, over those same decades, in the much more Clunn-ish Birmingham.

- In Davos, in the Swiss Alps, we find much the same four-fold allocation of transactions. But the Swiss forests, unlike those of Himalayan villagers, are physically sandwiched between the high pastures (communally owned) and the valley floor (privately owned fields, houses and hotels). Over the many centuries that the Davos valley has been settled, both the fields and the pastures have expanded at the expense of the forest. But the trees on the steeper intervening slopes have stayed in place, acting as both a source of timber and as a barrier against avalanches. However, it is difficult (impossible, perhaps) to achieve both these functions simultaneously, and the Davosers have often set in train changes in the forest's age structure which, decades later, have resulted in exceptional avalanches reaching the valley floor and threatening the destruction of the entire community.
- Every time this unpleasant surprise has befallen them, the Davosers have responded by switching their forest management onto the all-in-the-same-boat egalitarian style. Later, it has sometimes shifted to the hierarchical style, often to the individualist style (with farmers owning long thin strips of forest running all the way from valley floor to alpine pasture), and sometimes to the fatalist style (as happened, for instance, when the avalanche danger was clearly perceived yet extraction continued in response to the demands of various mining booms and, in more recent years, for ski-runs).

Always Learning, Never Getting It Right. Surely, you might think, the Davosers would have got it right by now, but to think that is to assume that there is one right way. However, there is no way of ever getting it right – permanently right, that is – because acting one way inevitably changes the forest, eventually to the point where that way of managing is no longer appropriate. This would happen even if there were no exogenous changes (like the mining and tourist booms) which of course there always are, even in seemingly remote places like the Himalaya. Viability can only be achieved, therefore, by covering all the bases: by the villagers ensuring that they have the full four-fold repertoire of management styles, and by their being prepared, through a process of argument and deliberation, to try a different one whenever the one they are relying on shows signs of no longer being appropriate. The Davosers, like their Himalayan counterparts, have now been in their valley for more than 700 years, without destroying either themselves or their valley in the process. This achievement would not have been possible if they had opted for just one management style (think of Alan Greenspan and his “self-interest ideology” that had served him so well until, in 2007, he, and everyone else, was hit by “a once-in-a-century credit tsunami”). Nor would it have been possible if they had opted for the two – markets and hierarchies – that the prevalent social science orthodoxy allows (“Wall Street” and “the White House” as they were dubbed post-the credit crunch, but no “Main Street”). It remains to be seen whether and how what has been good for village life can be just as good for the long-term viability and prosperity of cities.

4.3 Adaptation

Moving heaven and earth in order to remain in the same basin of attraction is doomed to failure. Since no strategy is good for all risk seasons, sticking with just one will inevitably

lead to a shift into a system-state – a new “risk season” – that will call for the adoption of a different strategy ... on and on. The lesson, from villagers in Nepal and Switzerland and from financial crises (from tulip mania to the 2008 credit crunch and its aftermath; see Mars and Thompson 2013), is that all four voices – all four strategies – have to be at the table, as it were, together with a degree of deliberation sufficient to ensure that, when a strategy that has been working well seems to no longer be effective, it can be replaced by one of the others: the one appropriate to the now-changed risk season. All four strategies, and the ability to switch between them with a minimum of delay, is therefore the essence of social resilience. Hence the need to move away from elegance and towards clumsiness. With resilience defined in this way, adaptation, too, changes. Far-sighted, top-down and expert-planned shifts in behaviour and technology, which is where so much of the present effort (especially in relation to climate change) is being expended, is only one of the four balls that need to be kept in the air. And to perform that juggling feat we will need the concept of *rational adaptation*, not to mention some interesting and novel forms of computational foresight.

A rationally adaptable firm, for instance, would change its risk strategy, appropriately, the moment its risk environment switched from one of its four possible seasons to another. Impossible in practice, of course, but we can do it, in simulation, with the help of an agent-based model: the “surprise game” as it is called (in which firms can be “rigged” to do all sorts of things they could never manage to do in real life; see Ingram et al 2012). The rationally adaptable firm, it turns out, does much better, in terms of both profit and bankruptcy-avoidance, than do the firms that stick with just one strategy regardless of the changing seasons. And those firms that change but always get it wrong – the ultimate “bad luck firms” – unsurprisingly, do worst of all. Rational adaptability, you could say, is akin to the physicist’s “ideal gas” or “black body”; it is very useful even though you can’t have it! What we *can* do, however, once we have this ideal construct, is shift ourselves *in that direction* by ensuring that we are clumsy. With each of the four voices clearly heard, and responded to by the others, we are more likely, having not rejected any of the valid knowledge as uncomfortable, to pick up on the fact that the risk season has changed, and better placed to make the appropriate change sooner rather than later.

But, if we have sunk massive costs into a strategy that is evidently no longer the appropriate strategy, it is going to be that much more difficult to make the required shift. Indeed, we could even find ourselves in a situation where the sunk costs are so great that they will outweigh the benefits we would get from making the change of strategy. In other words, through our excessive elegance, we will have boxed ourselves into “unwarranted fatalism”. All of which brings us to path dependence.

4.4 Path dependence

It is non-ergodicity – small, random historical events not cancelling themselves out in the aggregate – that is responsible for path dependence. Since some processes of change are non-ergodic and some are ergodic, we would be well advised to be wary of neoclassical economics, because it has set off from the assumption that *all* our transactional processes are ergodic. There is a joke (well, perhaps it is not a joke) about the economics faculty at the University of Chicago who, when they heard you can tell a science has become mature when it can afford to ignore its history, did away with economic history as a compulsory module. But in a mature science – physics, say – history can be ignored because, regardless of the path you have taken, you will end up with the same laws of thermodynamics, the same Avogadro’s number and so on. The destination, in other words, is not in any way determined by the path taken. The process

is (or, rather, has become) ergodic. However, that is not the case with economics; even less so with the city.

This is because (or largely because) the costs that are inevitably sunk into any strategy are being sunk into technologies (as with those high-rise systems-built tower blocks in the 1960s and, if it gets the go-ahead, the proposed HS2 rail link from London to Birmingham and beyond). In consequence, we can easily find ourselves locked-in by small and random events to a particular technology, even though there might be a more efficient alternative available (see Box F: Competing Technologies Under Increasing Returns to Scale). Most technological lock-ins, of course, happen in a less accidental way, thanks to pre-existing institutional commitments (as we see with those tower blocks and with HS2) but the clinching blow in the current struggle between neoclassical economics and the upstart evolutionary economics is that lock-ins can happen even in the complete absence of pre-existing institutional commitments.

Box F: Competing technologies under increasing returns to scale

In the conventional economics account (as depicted in the dashed curve in Figure F.1) two competing technologies always lie on a smooth and single-trouged curve (and you will see this curve – sometimes reframed as the LRCC, the Long-Run Cost Curve – in every economics textbook). “Changes at the margin”, as economists call them, lead us very quickly to abandon the less efficient technology (Technology B, with its higher unit costs) and to latch onto the more efficient technology (Technology A, with its lowest possible unit costs). End of story! In other words, the market, as long as it is not being interfered with in some way, will always bring us to the most efficient technology. Not so, says Brian Arthur (1994, 2009). At any rate, not when, as is often the case, there are what are called “increasing returns to scale” (as for instance in “Nothing succeeds like success” or the biblical “To those that have shall be given and from those that have not shall be taken away even that which they have”).

In this increasing returns situation (and as is depicted in the solid curve in Figure F.1) tiny little events early on (Arthur gives numerous examples, all of which are hotly contested by those who cling to the conventional economics account) can result in us becoming “locked-in” to a less efficient technology. A few extra sales of Technology B, for instance (Arthur cites the Olds Brothers’ winning of a race with their internal combustion-engined car, and laying down their production line on the strength of that success) and no amount of changes at the margin will carry us away from it and down to the more efficient Technology A. The reason is that there are now two troughs to our curve, and changes at the margin, being uphill in both directions, just keep on bringing us back to our “local” trough. It would take what ecologists call an “optimal perturbation” – a whacking great jolt – to get us over the hump and then down the slope to the more efficient Technology A.

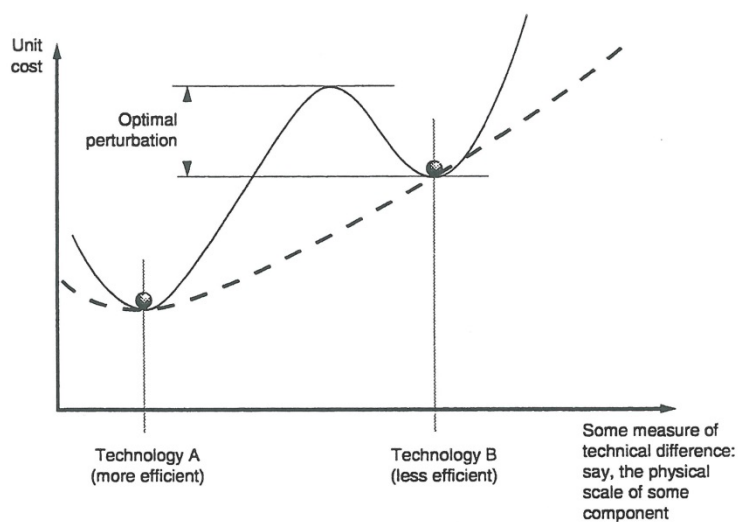


Figure F.1: Two accounts of technological competition

“This”, as the film director Sam Goldwyn exclaimed when the atom bomb was explained to him, “is dynamite!”. If the market can no longer be relied upon always to bring us onto the most efficient technological path then we are going to find ourselves locked into some horrendously wasteful lines of development.

Earth or water: a momentous decision

Back in the 1830s, two patents were registered in London: Thomas Crapper’s water closet and the Reverend Henry Moule’s (pronounced “Mole”) earth closet. The water closet, of course, got that tiny bit ahead, very early on, and the earth closet got nowhere (that’s why we talk a load of crap and not a load of moule¹⁶!) The result, nearly 200 years later, is that the entire developed world is massively locked into the technologies of sewerage and wastewater treatment. And, since the putting of human waste into the water cycle is now increasingly seen as a not wholly marvellous thing to have done, we might all be kicking ourselves and wishing that, all those years ago, things had swung the other way: to the Reverend Henry Moule and his earth closet. The cost involved, now, in delivering the optimal perturbation, and getting us onto that much more desirable (or should that be less crappy?) technological path, must run to trillions of dollars. Developing countries, like Nepal, however, not having got themselves locked into the water closet technology, face no such costs. As they say in business schools (but not, alas, in schools of development studies) “Why learn from your mistakes when you can learn from other people’s?”

However, though technological lock-ins are unavoidable, we *can* do something about the depth of those lock-ins; we can keep our technologies flexible, thereby avoiding boxing ourselves into those fatalising situations (by working with criteria such as the eight indicators of technological inflexibility first introduced by Collingridge (1981)). We can also do something to escape from those pernicious lock-ins (such as we have, in developed world cities, with fossil fuels and sewerage and wastewater systems) even though the costs of such escapes appear to rule it out. Such escapes, however, require “optimal perturbations”: massive and expensive (but nevertheless worthwhile)

¹⁶ But perhaps not. The word crap might derive from Middle English and from the Dutch crappa. There is a Henry Moule earth closet in the Dorchester Museum (he hailed from Dorset) – in a glass case, we hasten to add, the ones in the Ladies and Gents being all Thomas Crapper-type water closets.

jolts. They can never be achieved by the neoclassical economist's "changes at the margin".

Path dependence goes a long way towards explaining why attempts to generalize about cities – to create a "cityology", as it were – are always so disappointing. Each city, thanks to its history having had such a major hand in determining the way it currently is, has to be treated as a one-off. Even so, certain gross differences in the technological paths taken by cities that have lived through the Industrial Revolution and those that have not do allow us to make certain valid comparisons.

Northern cities (London is a prime example) face a double challenge in coping with change: they need to ensure that the technologies they are about to choose are flexible, and they need to find ways of escaping from the horrendously deep lock-ins they currently have, thanks to their having lived through two centuries-worth of technological inflexibility. Southern cities, however, do not face the second challenge. Kathmandu, for instance, may have a profusion of flush toilets but it has no wastewater infrastructure (unless you count the evil-smelling, but sacred, Bagmati River). Nor is it deeply sunk into the technologies of fossil fuel, as is evident from the ease with which it has been able to switch all its "tuk-tuks" across to renewable energy. And, out on its periphery, peasant farmers have had no great difficulty in switching their ropeways to hydroelectricity and their cooking and lighting to biogas. Southern cities, in consequence, are in a position to leap-frog ahead of their Northern counterparts. Whether they do, however, depends on whether they opt for clumsiness or stick with the elegance that is being urged on them by the international donor community.

5. Finally, connecting the systemic dots

Looking back to the distant past, when Geels (2005, 2006) sought to understand the historical, socio-technological transformations in the water infrastructure of Dutch cities at the turn of the 19th to the 20th century – from non-piped to piped water supply, and from cesspools to piped sewerage – he was obliged to take 80- and 90-year spans of time in order to carry out his analyses satisfactorily. These were slow shifts of paradigm. And no-one at the time had the benefit of access to any computational mathematical models and foresight, to contemplate the unfolding of these shifts or to determine how to intervene to influence their course. Among the many profound differences of circumstance and technology between the turns of the 19th-20th and 20-21st centuries, access to computational foresight is surely one of them.

So how is clumsiness going to be put to work on a contemporary challenge of strategic significance for cities stretching out to 2065 and beyond?

5.1 Clumsiness and computational foresight

Looking to that distant future, therefore, two questions arise. First, how might access to computational foresight influence today the occurrence and passage of what Geels refers to as a strategic Sustainability Transition? And, second, will such access shorten (or lengthen) the process of future transformation, the equivalent of which, a century ago, took many decades to occur? In closing our paper, we examine these questions briefly, from the perspective of wicked problems, uncomfortable knowledge and, in particular (of course), clumsiness in governance, policy-making, innovation, and coping with change.

How indeed should urban communities, city governments, and their policies and innovations be (clumsily) responsive to the ever co-evolving (and, ultimately, unpredictable) drivers of change in the human, the built, and the natural environments that make up city-hinterland systems? “Expect the Unexpected” is how Holling saw things at the end of the 1970s (Holling, 1979). Three decades on, this was likewise how management consultancy firm KPMG saw the global economic-environmental challenges of the 21st century (KPMG, 2012).¹⁷ For our part, we imagine all those holding a stake in the framing of urban policy to be in a state of relaxed-but-alert apprehension, with as many as possible plural and peripheral visions of the future in mind. We imagine computational foresight being accessed within what we have referred to above (in respect of sustainability) as Waddington’s (1957) epigenetic landscape of a complex dynamical system – within the adaptive cycling of Figure 2, therefore, hence in a socially and ecologically resilient sense.

To see how such foresight might work computationally (and socially), let us call upon our theory of plural rationalities and its associated solidarities and actors one last time. Our assertion is that, if/when clumsiness is adopted more fully in the practice of city affairs, it will liberate opportunities for rather novel approaches to the generation and utilisation of computational foresight. The beginnings of such approaches are foreshadowed in our research of over a decade ago, in Beck et al (2002) and Beck (2002) (which implies their practical mobilisation and acceptance may yet have another decade to wait and mature). Further refinements have been added more recently (Beck, 2011; Beck et al, 2013; Beck,

¹⁷ Though Oscar Wilde is credited with coining the phrase.

2014b). They make much more apparent the way in which this means of generating computational foresight may be grounded in our theory of plural rationalities and clumsiness.

Thus, we suppose any community's, any solidarity's, hopes, fears, and aspirations for the future may be expressed – under *gross* uncertainty, if necessary – as a (quantitative) description of future behaviour of the system, e.g., the city, and its logical (Boolean) complement, future “not-the-behaviour”¹⁸ of the city. And here is how our solidarities might assemble their respective aspirations:

- *Egalitarian* actors, in particular, will imagine all manner of things going wrong in the future. The more of them, and the more bizarre they are, so much the merrier (Beck, 2002, 2014b). Specifically, for instance, Rockström et al (2009), as we have already mentioned, have assembled nine interlinked planetary boundaries reflecting thresholds or tipping points that “must not be transgressed” for humanity to preserve a “safe operating space”. In these alone, there are the means to construct nine future behaviours (of the planet, in their case) and nine complementary “not-the-behaviours”, where behaviour and not-the-behaviour are simply and conceptually divided by the threshold.¹⁹
- Those holding to the *hierarchical* view of the world would opt for a singular, consensual vision. Their (desired) future behaviour might be circumscribed by the two peaks either side of the shallow trough in Figure 1, with then the complement of not-the-behaviour amounting to all that which lies outside and beyond (both) boundaries.
- Upholders of *individualism*, if they have a view of the future, would believe it to be (singularly) “essentially the same” as that which has been observed in the past, with then the complement of not-the-behaviour encompassing (in a non-specific manner) everything else. This “everything else” we may label as future behaviour that is “radically different” from anything we have ever witnessed before, which may happen to embrace something of what the egalitarian actors, in particular, specifically imagine.

Besides this plurality of strategic aspirations for the distant future form and function of the city,²⁰ something else is both distinctive and crucial about our approach. For our essential purpose is to enquire into which *few* elements of the (uncertain) knowledge encoded in the computational model are key to determining the reachability, or not, of any future societal aspiration. Such elements of knowledge may come in the form of elements of the science base, items of technological innovation, or constituents of candidate policies. One needs to know much more about the *key* factors (and the sooner the better), as opposed to the hundreds, possibly thousands, of other elements in the model that conversely appear to be *redundant*, in discriminating, that is, whether the expressed future hopes and fears are attained or not.

¹⁸ These seemingly strange devices are needed for a particular form of computational foresight, as set out in Beck (2002) and Osidele and Beck (2003) in a case study of managing the long-term ecological health of Lake Lanier, just to the north of Atlanta, USA.

¹⁹ Ceasing of the North Atlantic Ocean conveyor belt is one such threshold, cited as the original, archetypal motivation for our computational approach in Beck (2002). Since this vision does allow a “safe operating space” – though very constricted – it is best seen as an egalitarian/hierarchical hybrid. Full-blooded egalitarianism allows neither a safe space nor the time for any elaborate modelling.

²⁰ These “respective aspirations”, we hasten to add, are not the whole story. The theory tells us considerably more about constructions of time (and space) and about future expectations (see Rayner 1984; Douglas et al 2000; Thompson 2003b).

Affairs would not be decided “once and for all”. Our notions of Rational Adaptation and Adaptive Community Learning (Beck et al, 2002; Beck, 2011) would have full reign.

There is no equilibrium: no end-of-the-road – be it ecological or institutional – where matters finally come to rest. The idea of a one-way transition from the swashbuckling “pioneer community” to the intricately structured and optimised “climax community” – in which the very word climax expresses all that we should ever want – is profoundly mistaken. Rather, our ways of coping with change make future change – and future changes in coping strategies – inevitable. Initiating deliberate, strategic change by any actor or any set of actors rarely, if ever, unfolds in the manner conceived and intended by the instigator. And yet, we argue, handling change, either passively or actively, benefits from the interplay of the four (not two, not one) discourses, i.e., from the four ways of seeing the world and acting within it. What is more, we argue further, the changes that are experienced are more likely to be for the better for *all* four actor types than would otherwise be the case, in the absence of clumsiness.

5.2 A candidate challenge: smarter urban metabolism

In the face of contemporary climate change, the dominant technological thrust for changing the infrastructure of cities goes under the slogan of our “low-carbon futures”. It is possible we could attain these. But no matter how “low-carbon” might be the innovative futures of UK cities, they will still be relatively high-nitrogen, high-phosphorus, and (indeed) high dietary-carbon futures. People will still have to eat, hence create post-consumption N, P, and C resource flows in city sewage and like flows in the food materials wasted prior to consumption.

Flows of *resources*, however, are decidedly *not* how these are currently perceived, but as pollutants – as water pollutants, in fact, given the stunning success of Mr Crapper’s WC some 150 years ago. From that device, as we well know, has flowed the subsequent, progressive, historical social and technological lock-in to the water and, in particular, wastewater infrastructure of cities. And for half a century, if not longer, engineers have been perfecting the technology of wastewater treatment for “eliminating” the perceived N and P pollutants prior to discharging the water reclaimed from the wastewater back to the aquatic environment. In the process, much energy is consumed through wastewater treatment in shunting the vital, reactive species of N – those that grow “good” green things on the land and “bad, polluting” green things in water – into the unreactive molecular gaseous (N₂) species, only for a great deal of energy then to be invested through the Haber-Bosch process in generating those same reactive N species as fertiliser to put on the ground, from the unreactive nitrogen gas in the atmosphere.

In the round, this is not a good way of contributing to a low-carbon future, quite apart from the intrinsic value to society of recovering and recycling the post-consumption N and P (as well as the dietary C). In short, the grand challenge is to effect a radical and transformative change, from one basin of massively strong attraction to something other: from viewing the nutrients N, P, and C as the polluting “waste” in “waste”water, to be rid of a.s.a.p.; to seeing them as resources to be beneficially recovered. The challenge is as much one for society as for technology (Beck et al 2012). If we could make the change to this alternative basin of attraction, we should call it a “smarter urban metabolism” (Beck et al 2013).

In the case of London, for instance, the eventual economic prize might amount to a total of some \$375M per annum, comprised of profits from sales of fertiliser, biofuels, and C-

credits, together with savings from reduced water and energy consumption (see “Growing Profits from Growing Rainbow”; available from <http://cfgnet.org/archives/1292>). A large proportion of this potential bounty turns on the single, humble innovation of a urine-separating toilet, since urine is the richest post-consumption concentrate of N and P resources. Handling (rather, mishandling) N and P as pollutants does not have to be an endless drain on the public purse. “Climate change”, might run the headline, “drives the profitable market for urine-separating toilets”. Indeed, these devices might well qualify as “privileged, non-foreclosing interventions” (Beck et al 2013; Villarroel Walker et al 2014). They would not foreclose, in principle, on the attainability of any of the plural societal aspirations and hopes for the distant future. They could be implemented “today”. Yet they would be reviewed and revisited again and again as the “disequilibrating dynamical system” comprising the coupled human-built-natural environments of the city (and its hinterland) reveals its actual future behaviour step by step.

A very large economic jolt, however, will be needed to realise the eventual bounty of beneficially recovering the resources currently treated as the waste in “waste”water, possibly off the scale of Figure F.1 in Box F. And it will need to be one doubtless pre-conditioned on a transformed social perception of post-consumption (sewage) resource flows – just as we now have with regard to solid forms of household food residues, packaging, paper, and so on. In this instance, of course, and in contrast to London’s housing stock in the 1950s and 1960s, the physical properties of the “waste” (or rubbish) *are* subject to biochemical transformation *and* recycled (as opposed to being just re-valued).

Would access to some computational foresight make such urgent and much sought-after “transformative changes” come about more rapidly than might otherwise be the case? In contemplating this question, we have already been given pause for thought in this case study of London attaining a smarter metabolism (Beck et al 2013). Once one begins to generate foresight about “who might gain, who might pay”, not to mention to recognise that there can be *plural* computational models (i.e., plural beliefs about the way the world works) the scope for debate and dispute over yet larger volumes of decidedly even more uncomfortable knowledge could expand beyond our wildest dreams (or nightmares, should this be?).

References

Arthur, W.B. (1989). Competing technologies, increasing returns, and lock-in by small historical events. *Economic Journal*, 99: 116-131.

Arthur, W.B. (2009). *The Nature of Technology*, London: Allen Lane.

Ayres, R.U. and Simonis, U.E. (1994). *Industrial Metabolism: Restructuring for Sustainable Development*. Tokyo: United Nations University Press.

Beck, M.B. (ed.) (2002). *Environmental Foresight and Models: A Manifesto*. Oxford: Elsevier.

Beck, M.B. (2011). *Cities as Forces for Good in the Environment: Sustainability in the Water Sector*. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, Georgia, (ISBN: 978-1-61584-248-4), xx + 165pp (online as <http://cfqnet.org/archives/587>).

Beck, M.B. (2014a). Sustainability and smartness: a tale of two slogans. *Sustainability of Water Quality and Ecology*, 1-2: 86-89 (<http://dx.doi.org/10.1016/j.swage.2014.05.002>).

Beck, M.B. (2014b). Handling uncertainty in environmental models at the science-policy-society interfaces. In M. Boumans, G. Hon, and A.C. Petersen (eds.) *Error and Uncertainty in Scientific Practice*. London: Pickering and Chatto: 97-135.

Beck, M.B., and Villarroel Walker, R. (2013). Nexus security: governance, innovation and the resilient city. *Frontiers of Environmental Science & Engineering*, 7(5): 640-657.

Beck, M.B., Fath, B.D., Parker, A.K., Osidele, O.O., Cowie, G.M. Rasmussen, T.C., Patten, B.C., Norton, B.G., Steinemann, A., Borrett, S.R., Cox, D., Mayhew, M.C., Zeng, X-Q., and Zeng, W. (2002). Developing a concept of adaptive community learning. Case Study of a Rapidly Urbanizing Watershed. *Integrated Assessment*, 3(4): 299-307.

Beck, M.B., Thompson, M., Ney, S., Gyawali, D., and Jeffrey, P. (2011). On governance for re-engineering city infrastructure. *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, 164(ES2): 129-142.

Beck, M. B., Villarroel Walker, R. and Thompson, M. (2012). Changing the metabolism of coupled human-built-natural systems. In R.J. Dawson, C.L. Walsh and C.G. Kilsby (eds.) *Earth Systems Engineering 2012: A Technical Symposium on Systems Engineering for Sustainable Adaptation to Global Change*, Centre for Earth Systems Engineering Research, Newcastle University, UK: 11-32.

Beck, M.B., Villarroel Walker, R. and Thompson, M. (2013). Smarter urban metabolism: earth systems re-engineering. *Proceedings of the Institution of Civil Engineers – Engineering Sustainability*, 166(ES5): 229-241.

Billen, G., Garnier, J., and Barles, S. (2012). History of the urban environmental imprint: introduction to a multi-disciplinary approach to the long-term relationships between western cities and their hinterland. *Regional Environmental Change*, 12: 249-253.

Bloor, D. (1984). Polyhedra and the abominations of Leviticus. In M. Douglas (ed.) *Essays in the Sociology of Perception*. London: Routledge and Kegan Paul: 191-218.

- Brunner, P.H., and Rechberger, H. (2003). *Practical Handbook of Material Flow Analysis*. Boca Raton, Florida: Lewis.
- Brion, D.J. (1992). The meaning of the city: urban redevelopment and the loss of community. *Indiana Law Review*, 25.3.
- Checkland, P. (1985). The approach to plural rationality through soft systems methodology. In M. Grauer, M. Thompson and A Wierzbicki (eds.) *Plural Rationality and Interactive Decision Processes*. Berlin: Springer: 8-21.
- Clunn, H.P. (undated but probably between 1938 and 1947), first edition was circa 1950 and second edition circa 1954) *The Face of London*, London: Spring Books.
- Collingridge, D. (1981). *Social Control of Technology*. Milton Keynes: Open University Press.
- Dahl, R. (1971). *Polyarchy: Participation and Opposition*. New Haven, CT: Yale University Press.
- Douglas, M. (1970). *Natural Symbols: Explorations in Cosmology*. London: Cresset Press.
- Douglas, M., Thompson, M. and Verweij, M. (2003). Is time running out? The case of global warming. *Daedalus*, Spring: 98-107.
- Durkheim, E. (1893). *De la Division du travail Sociale: etude sur l'Organisation des Sociétés Supérieures*. Paris: Alcan.
- Fehr, M. (2005). Art-museum-utopia: five themes on an epistemological construction site. In J. Rusen, M. Fehr and T.W. Rieger *Thinking Utopia*. Oxford: Berghahn Books: 169-73.
- Fergusson, A. and Mowl, T. (1989). *The Sack of Bath – And After*. Salisbury: Michael Russell.
- Fischer-Kowalski, M. and Haberl, H. (1993). Metabolism and colonisation: modes of production and the physical exchange between societies and nature. *Innovation in Social Science Research*, 6.4: 415-442.
- Fischer-Kowalski, M. and Haberl, H. (1998). Sustainable development: socio-economic metabolism and colonisation of nature. *International Social Science Journal*, 158: 573-587.
- Gallie, W.B. (1955). Essentially contested concepts. *Proceedings of the Aristotelian Society*, 56: 167-198.
- Geels, F. (2005). Coevolution of technology and society: the transition in water supply and personal hygiene in the Netherlands (1850-1930) – A case study in multi-level perspective. *Technology in Society*, 27: 363-397.
- Geels, F. (2006). The hygienic transition from cesspools to sewer systems (1840-1930): The dynamics of regime transformation. *Research Policy*, 35: 1069-1082.
- Gyawali, D., Thompson, M. and Verweij, J.M. (eds.) (2015). *The Toad Beneath the Harrow* (forthcoming).

- Hendriks, F. (1994). Cars and culture in Munich and Birmingham: The case of cultural pluralism. In D.J. Coyle and R.J. Ellis (eds.) *Politics, Policy and Culture*. Boulder, Colorado: Westview Press.
- Hofstetter, P. (1998). *Perspectives in Life Cycle Impact Assessment*. London: Kluwer.
- Holling, C.S. (1973). Resilience and stability of ecological systems", *Annual Reviews of Ecological Systems*, 4: 1-23.
- Holling, C.S. (1979). Expect the unexpected: an adaptive approach to environmental management. *Executive Report ER-79-001*, International Institute for Applied Systems Analysis, Laxenburg, Austria.
- Holling, C.S. (1986). The resilience of terrestrial eco-systems: local surprise and global change. In W.C. Clark and R.E. Munn (eds.) *Sustainable Development of the Biosphere*. Cambridge: Cambridge University Press: 292-320.
- Holling, C.S. (1996). Engineering resilience versus ecological resilience. In P. Schulze (ed.) *Engineering Within Ecological Constraints*. Washington DC: National Academy Press: 31-44.
- Holling, C.S., Gunderson, L.H. and Peterson, G.D. (2002). Sustainability and panarchies. In L.H. Gunderson and C.S. Holling (eds.) *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC: Island: 63-102.
- Ingram, D., Taylor, P. and Thompson, M. (2012). Surprise, surprise: from neoclassical economics to e.life. *ASTIN Bulletin (Journal of the International Actuarial Association)*, 42(2): 389-412.
- Ingram, D., Thompson, M. and Underwood, A. (2013). All on the same train but headed in different directions. Chief Risk Officers' Council: www.crocouncil.org/2013/callforpapers.html.
- Ives, J.D. (2004). *Himalayan Perspectives*. London and New York: Routledge.
- Katz, I. (1996). *Pulling the plug on progress*. The Observer (London), 14 April.
- Kim, E. and Barles, S. (2012). The energy consumption of Paris and its supply areas from the eighteenth century to the present. *Regional Environmental Change*, 12: 295-310.
- KPMG (2012). *Expect the Unexpected. Building Business Value in a Changing World*. [Available on-line at www.kpmg.com/global/en/issuesandinsights].
- Lakatos, I. (1976). *Proofs and Refutations: The Logic of Mathematical Discovery*. Cambridge: Cambridge University Press.
- Lietaer, B., Ulanowicz, R. and Goerner, S. (2009). Options for managing a systemic bank crisis. *S.A.P.I.E.N.S.* [Online], 2.1, Online since 6 April 2009. Url: <http://sapiens.revues.org/747>.
- Lindblom, C. (1977). *Politics and Markets: The World's Political Economic System*. New York: Basic Books.

- Lynas, M. (2011). *The God Species: How the Planet Can Survive the Age of Humans*. London: Fourth Estate.
- Maine, H.S. (1861) *Ancient Law*. London: John Murray.
- Mars, G. and Thompson, M. (2013). Individualism versus hierarchy: Kondratieff and his crime waves; the behavioural underpinnings of booms and slumps. In G. Mars *Locating Deviance: Crime, Change and Organizations*. Farnham: Ashgate.
- Martin, R. and Sunley, P. (2014). On the notion of regional economic resilience: conceptualisation and explanation. *J Economic Geography*, doi:10.1093/jeg/lbu015.
- Meadows, D.H., Meadows, D.L. and Randers, J. (1972). *The Limits to Growth*. New York: Universe Books.
- Meadows, D.H., Meadows, D.L. and Randers, J. (1992). *Beyond the Limits*. London: Earthscan.
- Ney, S. (2009) *Resolving Messy Policy Problems*. London: Earthscan.
- Nordhaus, T., Shellenberger, M. and Blomqvist, L. (2012). *The Planetary Boundaries Hypothesis: A Review of the Evidence*. Oakland, California: The Breakthrough Institute.
- Osidele, O.O., and Beck, M.B. (2003). An inverse approach to the analysis of uncertainty in models of environmental systems. *Integrated Assessment*, 4(4): 265-283.
- Peterson, G.D., Allen, C.R. and Holling, C.S. (1998). Ecological resilience, biodiversity, and scale. *Ecosystems*, 1: 6-18.
- Putnam, R.D. (1993). *Making Democracy Work: Civic Traditions in Modern Italy*. Princeton, NJ: Princeton University Press.
- Rayner, S. (1984). Disagreeing about risk: the institutional cultures of risk management and policy for future generations. In S. R. Hadden (ed) *Risk Analysis, Institutions and Public Policy*. Port Washington, New York: Associated Faculty Press: 150-169.
- Rayner, S. (2012). Uncomfortable knowledge: the social construction of ignorance in science and environmental policy discourses. *Economy and Society*, 41(1): 107-125.
- Rittel, H.W.J. and Webber, M.M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4.2:155-169.
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H-J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P., and Foley, J.A. (2009). A safe operating space for humanity. *Nature*, 461 (24 September): 472-475.
- Salingaros, N.A. (2005). *Principles of Urban Structure*. Amsterdam: Techne Press.
- Samuelson, P. (1948). *Economics*. New York: McGraw Hill.

- Schmidt-Bleek, F. (1994). *Wieviel Umwelt braucht der Mensch: MIPS – Das Mass für ökologisches Wirtschaften*. Basel: Birkhäuser Verlag.
- Shapiro, M. (1988). Judicial selection and the design of clumsy institutions. *Southern California Law Review*, 61: 1555-1569.
- Smith, A. and Stirling, A. (2010). The politics of socio-ecological resilience and sustainable socio-technical transitions. *Ecology and Society*, 15(1): 11 [online] URL: www.ecologyandsociety.org/vol15/iss1/art11/.
- Snidal, D. (1991). Relative gains and the pattern of international cooperation. *American Political Science Review*, 85: 701-26.
- Taleb, N.N. (2012). *Antifragile. Things That Gain from Disorder*, New York: Random House.
- Thompson, M. (1979). *Rubbish Theory: The Creation and Destruction of Value*. Oxford: Oxford University Press.
- Thompson, M. (2002). Man and nature as a single but complex system. In T. Munn (ed-in-chief) *Encyclopaedia of Global Environmental Change*. Chichester: John Wiley: 384-93.
- Thompson, M. (2003a). Stoffströme und moralische Standpunkte. In M. Fansa and S. Wolfram (eds.) *Müll: Facetten von der Steinzeit bis zum Gelben Sack*. Mainz am Rhein: Verlag Philipp von Zabern.
- Thompson, M. (2003b). Time's square: deriving cultural theory from rubbish theory. *Innovation*, 16(4): 319-330.
- Thompson, M. (2008). *Organising and Disorganising*. Axminster: Triarchy Press.
- Thompson, M (2010). A bit of the other: why scarcity isn't all it's cracked up to be. In L. Mehta (ed) *The Limits to Scarcity. Contesting the Politics of Allocation*. London: Earthscan: 127-142.
- Thompson, M. (2011). Sustainability is an Essentially Contested Concept. *Surveys And Perspectives Integrating Environment & Society*, [Outline], 4.1, online since 23 November 2011, <http://sapiens.revues.org/1177>.
- Thompson, M. and Gyawali, D. (2007). Uncertainty revisited or the triumph of hype over experience. Introduction to new edition of M. Thompson, M. Warburton and T. Hatley *Uncertainty on a Himalayan Scale*. Lalitpur, Nepal: Himal Books.
- Thompson, M. and Rayner, S. (1998). Cultural discourses. In S. Rayner and E.L. Malone (eds) *Human Choice and Climate Change*. Columbus, Ohio: Battelle Press: Vol. 1: 195-344.
- Thompson, M., Ellis, R., and Wildavsky, A. (1990). *Cultural Theory*, Boulder, Colorado: Westview.
- Tönnies, F. (1887). *Gemeinschaft und Gesellschaft*. Darmstadt: Wissenschaftlich. (Translated as *Community and Society*, 1957, by C.P. Loomis, East Lansing, MI: Michigan State University Press.)

- Verweij, M. (2011). *Clumsy Solutions for a Wicked World*. Basingstoke: Palgrave Macmillan.
- Verweij, M. and Thompson, M. (eds) (2011). *Clumsy Solutions for a Complex World* (new paperback edition). Basingstoke: Palgrave Macmillan.
- Villarroel Walker, R., and Beck M.B. (2012). Understanding the metabolism of urban-rural ecosystems: a multi-sectoral systems analysis. *Urban Ecosystems*, 15(4): 809-848.
- Villarroel Walker, R., Beck, M.B., Hall, J.W., Dawson, R.J., and Heidrich, O. (2014). The energy-water-food nexus: strategic analysis of technologies for transforming the urban metabolism. *J Environmental Management*, 141: 104-115.
- Vitousek, P.M., Ehrlich, P.R., Erlich, A.H. and Matson, P.A. (1986). Human appropriation of the products of photosynthesis. *BioScience*, 36.6: 368-73.
- Waddington, C.H. (1957). *The Strategy of the Genes*. New York: Allen and Unwin.
- Walker, B. H., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S. and Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in socio-ecological systems. *Ecology and Society*, 11(1): 13 [online] URL: www.ecologyandsociety.org/vol11/iss1/art13/.
- WCED (1987). *Our Common Future*. World Commission on Environment and Development. Oxford: Oxford University Press.
- Williamson, O. (1975). *Markets and Hierarchies: Analysis and Anti-Trust Implications: A Study in the Economics of Internal Organization*. New York: Free Press.
- Wright, D.H. (1990). Human impacts on energy flows through natural ecosystems, and implications for species endangerment. *Ambio*, 19.4: 189-94.
- 6, P. and Mars, G. (2008). Introduction. In P. 6 and G. Mars (eds.) *The Institutional Dynamics of Culture* (2 vols). Farnham: Ashgate: xv-xli.

