Pragmatism and Pluralism: Creating Clumsy and Context-Specific Approaches to Sustainability Science

Paul M. Weaver

1 Introduction

In the words of Tim O'Riordan, sustainable development is a 'tough nut to crack' because it does not fit easily with the normal political model of analysis and decision. The urgent need for sustainable development is evident, but the concept is vague, contradictory and confusing. O'Riordan points out that there is no agreement on what sustainability actually is, where we have to go to get it, and what it would look like in a multi-national world of nine plus billion people demanding more and more from a stripped and stressed planet (O'Riordan 2008). O'Riordan is right in that it is difficult to pin down what sustainable development is and what sustainability transitions will imply, for reasons which include that sustainability transitions are dynamic, systemic, configuration dependent, and indeterminate.

But whereas it may be difficult to pin down sustainability it is not difficult to pin down the mechanisms at play that make current pathways unsustainable and, from this, we can make further progress. We can highlight directionally-reliable trends for sustainability transitions to steer toward and push forward. We can obtain insights into steps that could be taken top-down to create market and regulatory framing conditions that would improve prospects for sustainability transitions generally, especially by increasing the degrees of freedom available for context-specific initiatives and innovations to emerge from bottom-up. Equally we can look at niche examples and contexts where transitions to apparently more sustainable ways of exploiting ecosystems and of creating sustainable livelihoods and wellbeing for community members are underway already. Importantly for the theme of this book and for those engaged in sustainability science we can also draw inferences about the roles science might play in supporting sustainability transitions. This is the core concern of the present chapter.

P.M. Weaver (✉)
Groundswell Research Associates
e-mail: pweaver.groundswell@gmail.com

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Clarifying the roles of science in sustainability is now an urgent issue. It may even be 'defining' for the prospects of sustainability transition. What happens next – that is whether effective progress on sustainability transition will be made – is on the cusp. Decisions and actions taken in the next 5–10 years will be profoundly important for the progress that is possible and whether the most serious consequences of unsustainable development can be averted, especially as concerns communities whose livelihoods and wellbeing are most vulnerable to environmental change threats and who are most marginalised by powerful macro-scale forces.

2 Purism Versus Pragmatism

In seeking to clarify what roles science could usefully and most effectively play in sustainability transitions, this chapter seeks to distinguish between 'purist' and 'pragmatic' stances. Purist stances stress the importance of a particular approach as being the 'key' for sustainability. These often stress a particular structural theme such as policies, markets or technologies and advocate typically whole-scale reforms to prevailing conditions on the themes concerned. Purism reflects particular stances in respect to the 'how' question of what might be done in a consistent, 'top-down' logic to chart future development pathways. Pragmatism, by contract, stresses that change processes in complex systems are multi-level, multi-dimensional and multi-speed and that innovations developed at lower levels of scale need to be adapted both to local contexts and to higher-level framing conditions and dynamics.[1] Pragmatism suggests that sustainability at the global level depends on achieving a patchwork of sustainable solutions at lower scale levels. In turn this stresses the need for combinations of mutually supportive and reinforcing top-down and bottom-up innovations that engage synergies among innovations on many different fronts.[2]

Science could play a critical role in delivering sustainability transitions. But the deployment of science and scientists in this endeavour to date has been ineffective (sometimes profoundly so) and may perhaps even have been counter-productive in some aspects. This will continue to be the case until the challenge that sustainable development represents to society and to scientists is better and more widely understood and, in turn, this is translated into new mandates for scientists and

[1] Other authors in this volume also point to the inherent paradoxes and contradictions of sustainable development, which complicate the process of achieving consensus and of establishing directions that are purist, unambiguous and non-controversial. To factor into the mix, also, is that pathways to sustainability need to be elaborated in context. Pluralism, diversity and context-specificity also are acknowledged leitmotivs for sustainable development.

[2] The analogy might be drawn in the contrast between 'purist' scenarios that scientists construct to help explore how different futures could unfold and which are typically delineated along the lines of dominant or leading themes and 'hybrid' scenarios that explore interactions among innovations of many different types. See, for example, the 'market first', 'security first', 'policy first' and 'sustainability first' scenarios developed for the Global Environment Outlook, UNEP 2007.

researchers. The roles such mandates specify for scientists are different from conventional and 'purist' roles and they call for a distinctive new form of science for sustainable development. We begin therefore by reflecting on key insights learned about sustainable development over the years since the concept first came to prominence, so that we might be able to better specify the challenge that sustainable development presents both to society at large and to those in the scientific and research communities who seek to support societal processes of sustainability transition.[3]

3 An Urgent Challenge

Making effective progress on sustainability transition is urgent and has been made so because each year there is an absolute increment in anthropogenic environmental stress. The global economy has become so large that even small rates of economic growth translate into large annual increments in absolute levels of economic activity, metabolic 'throughput', and stress. This absolute growth in the demands the global economy makes for environmental resources and ecosystem services is rapidly closing down any remaining distance to resource and ecological safety thresholds and is accelerating us toward these at the same time as these are 'closing in' because of anthropogenic environmental change. By contrast, no systematic progress is being made on poverty reduction in absolute terms.

Research over the last two decades has documented that the Earth is undergoing major environmental and socioeconomic changes (e.g. Steffen et al. 2004; UNEP 2007). Climate change, land degradation, deforestation, biodiversity loss, and changes of water quality and quantity are prominent examples of global environmental changes. Globalisation, demographic changes and the widening gap between rich and poor are examples of socioeconomic trends that are linked closely with such environmental changes. Recently a group of scientists proposed nine ecological boundaries or safety thresholds to preserve planetary mechanisms and environmental conditions on which humanity and much of the rest of the biosphere depends. They advised that these should not be crossed as this risks generating unacceptable environmental change for humanity (Rockström et al. 2009). Three of these may have been crossed already.

[3]This includes scientists and researchers, but also those who set research priorities and agendas, those who allocate and administer funds for research, and those who establish and implement the criteria used to evaluate research proposals and research outcomes.

4 Conventional Diagnoses

It is unsurprising, therefore, that one of the conventional diagnoses holds that the core challenge of sustainability is one of increasing the eco-efficiency with which goods and services are produced and consumed so that economic growth might be 'decoupled' from environmental stress. This diagnosis is unproblematic for the mainstream. It fits the prevailing development paradigm that equates progress with economic growth. It appeals to conventional political and business logics since it seemingly provides a 'way out' of the dilemma of ecological limits to growth. And it indicates a broadly conventional role for scientific work in support of sustainable development, for example in undertaking technical research into resource substitutions, developing eco-efficient technologies, increasing resource and energy productivities, and reducing emissions of wastes and pollution.

It is equally unsurprising that economic growth has historically been the dominant goal of modern societies, since the position from which modernisation began in most societies was typically one of material deprivation and hardship for the majority. More interesting in the current context is to understand why, as the richer societies have modernised and, one-by-one, have overcome material shortfalls and extended affluence across their populations, they continue to pursue further economic growth, even in the knowledge that this is raising ecological liabilities. This is largely because of mechanisms that are in-built in the way a modern market economy operates. These generate *either* spirals of growth *or* spirals of recession, but are unable easily to establish a 'steady-state'.

A market economy works by harnessing competition, which stimulates investment and innovation in a never-stopping search to increase returns to capital. Through innovation there is a continuous effort to improve the efficiency of using different factors of production. Innovation efforts focus on increasing the productivity of the more costly factors, since this increases total factor productivity and overall return to capital most effectively. On this basis, competition in the market achieves both increases in natural resource productivity and in labour productivity, but the dominant focus of innovation in markets as they are shaped now is to increase labour productivity, since labour is both relatively expensive as a factor of production and is a more problematic factor to manage and control relative to other factors, such as machinery, raw materials and energy.

The downside of increasing labour efficiency is that fewer workers are needed to produce the same output. Their unemployment risks reducing effective demand for goods and services in the economy. Sustaining social and economic stability – avoiding a recessionary spiral – therefore becomes a core concern of governments and businesses in market economies. Some stimulus to aggregate demand is provided by businesses passing on part of the cost reduction achieved by productivity improvement in the form of lower prices to consumers. Lower prices make goods more affordable and this can create a self-reinforcing cycle and engine for growth so long as the increase in aggregate demand encouraged by price reductions is sufficient to retain labour that would otherwise be released. Aggregate demand

may be stimulated or supported also by public spending or by increasing liquidity by providing consumers with easy access to credit. To limit the public debt burden of stimulating aggregate demand through public spending and deficit financing, some governments have preferred to use monetarist policies, which encourage and facilitate private debt as an alternative to public debt as a means to maintain consumption growth. The roots of the recent financial crisis lie in concerted effort to free up credit across the globe to support economic expansion (Jackson 2009). This is one reason why ecological and financial aspects of unsustainable development are systemically interlinked.

5 Self-defeating 'Decoupling'

For a market economy that is growth-oriented, further growth in the economy on a continuing basis therefore becomes necessary to secure economic, social, financial and political stability. This goes a good part of the way to explaining why growth is pursued as a conscious policy goal in its own right irrespective of whether production and consumption of goods and services at the margin is warranted in net benefit terms. It explains why there is political reticence to integrate resource depletion, pollution, and ecosystem degradation costs fully into the market, as well as social costs, since integration of these would make goods and services more expensive, reduce consumer demand, and risk recession. And it explains why so much emphasis has been placed on the strategy of 'decoupling'; i.e. increasing resource productivity as a way to 'decouple' economic growth from the material throughput of the economy. Intuitively decoupling appears to offer scope to reconcile the conflicting needs to expand growth (needed indefinitely to secure economic, financial and social stability as markets are formed now) while containing the physical scale of the economy (needed to ensure planetary boundaries are respected and that the economy stays within ecological safety zones).

Great store has been placed on decoupling. But it is clear from the discussion above that decoupling is not a plausible strategy of itself to deliver sustainability transition. Certainly to reduce the throughout of the economy there is a need to make improvements in resource efficiency and to reduce the pollution intensity of goods and services per unit of GDP. Relative decoupling of GDP from throughput is a necessary condition for ecological sustainability. But it is not a sufficient condition. For the throughput of the global economy to be reduced absolutely, which is what matters for global ecological sustainability, the rate of eco-efficiency improvement must be large enough annually to offset the combined impact of growth in population and growth in average income. It would be needed also for the eco-efficiency gain to be 'captured' and 'dedicated' to reducing the absolute throughput of the economy, rather than being redeployed to support economic growth. Yet the market is structured and oriented currently in a way that ensures that gains in efficiency to all factors of production are dedicated to expanding consumer demand.

Under present market arrangements investment in research and technology development to accelerate eco-efficiency is therefore unlikely to translate into absolute decoupling. Counter intuitively, to the extent that innovation efforts are successful in delivering specific efficiency and productivity improvements, such as reductions in CO_2 emission intensity at the level of specific products and services, this may even make matters worse, not better. Neither is it safe to rely on the argument that increasing affluence will ultimately provide an automatic mechanism for societies to switch away from economic growth. As markets are structured currently growth has its own dynamic unrelated to any material benefits of production and consumption. There is no reason (or credible evidence) to expect a production and consumption 'ceiling' above a certain level of affluence or for absolute decoupling to occur automatically once this level has been attained. In short, there is little likelihood under current market arrangements to 'grow out' of the problem or to assume the problem can be solved with a purely technical fix. Absolute decoupling at the global scale is a highly improbable outcome as markets are currently structured.

6 The Significance of the Market

Important here is the importance of the market and its construction in terms of global economic, social and environmental dynamics and outcomes. The market constitutes the dominant mechanism for strategic coordination at global scale. It is unrivalled in this role. Effectively the market operates de facto as *the mechanism of global governance*. How the market is structured and formed and how this orientates and harnesses key forces and directs resources is critical in shaping economic, social and ecological futures. As the market is formed and operates currently, the relationships between market processes and sustainable development are ambiguous at best. Some progress is being made on increasing relative eco-efficiency, but the rates of progress are below those needed and the productivity gains are not being captured to reduce absolute levels of environmental stress. Environmental change is already upon us and therefore cannot be ignored. Equally, although levels of economic output continue to expand, the gap between rich and poor is widening, not closing.

None of this is to argue against markets or globalisation processes. To the contrary there is a strong case to be made for making progress toward (re)forming markets and globalisation processes so that their powerful capacities for stimulating and coordinating innovation are directed and harnessed toward a widespread restructuring of production-consumption systems and a more sustainable exploitation and protection of critical ecosystems. The relationships between market processes and sustainable development are complex, ambiguous, and configuration-dependent, so a more nuanced understanding of important constituent mechanisms and drivers of market processes and a better differentiation of widely used terms, such as growth, globalisation, investment, innovation, and productivity, would help reveal how the

processes might be made more compatible. Current uses of these terms are ambiguous because they conflate ends and means and fail to distinguish adequately between different contexts and targets.

Growth is still needed in poorer countries to overcome poverty. By contrast, a shift away from further material growth in the already wealthy countries would help release environmental space for growth elsewhere. Global savings still need to be marshalled worldwide, but for the purpose of directing these into ecological investments of various forms rather than of using them as sources of cheap and unsecured credit to bolster consumer spending in the already- richer countries. Innovation is needed to increase eco-efficiency massively, but frameworks are needed to enable the gains to be captured to secure absolute reductions in the throughput of the global economy. By contrast, innovation to improve labour productivity is likely to be counterproductive in many contexts, especially where this causes social and livelihood insecurity needlessly. Greater precision and differentiation when using such terms would have important implications for policy, especially concerning the longer-term scope for introducing market reforms that could help to better align market processes with sustainable development targets.

Equally, the global-scale nature of environmental change and related economic, technological and social change processes means that the issues involved cannot be addressed effectively without cooperation at the global scale and without deliberate efforts to coordinate between local- and global- scale responses and between richer and poorer countries and communities. This is easy to demonstrate. In the case of climate stabilization, for example, it is now acknowledged that the richer countries of the OECD acting alone could not put the world onto a 450 ppm trajectory, even if they were to reduce their own CO_2-eq emissions to zero (International Energy Agency 2008). In the same vein there is an inherent symmetry in the approaches needed to manage and protect global-scale and local-scale common pool resources. Decisions by the international community to try to protect globally- and internationally- significant common pool resources, such as the atmosphere, critical habitats and biodiversity, and to develop supporting mechanisms including more extensive use of PES (payments for ecosystem services) schemes, depend for effective implementation on how local communities in regions such as Latin America manage and exploit critical local ecosystems, such as forests, mangroves and coral reefs, which are also, often, common pool resources.

Against these insights a broader debate about sustainable development is now opening up. A starting point has been to revisit the question of how wellbeing, happiness and prosperity are constituted and of the roles of production, consumption and formal economic activity in their delivery. Clearly wellbeing has a material dimension, relating to the fulfilment of basic needs for food, water, shelter and clothing, but it also has psychological and social dimensions, relating to whatever contributes to giving meaning and purpose in life. Wellbeing and happiness can be produced and delivered in many very different ways: via goods and services produced through formal economic activities, through direct ecosystem services, through services provided by public infrastructures, through relationships between and among individuals and society, etc. There are different degrees of

substitutability among different sources and forms of wellbeing. Basic material needs are not easily substitutable whereas psychological and social wellbeing may be fulfilled in very different ways. Some sources of wellbeing may be damaged or degraded in producing others. The situation is therefore complex and dynamic. Empirical studies reveal that at low levels of income per capita, increases in income contribute substantially to improving life quality, wellbeing and happiness. However, this direct correlation levels off at around $15,000 per capita. Growth in per capita income above this level does not appear to add significantly to wellbeing or happiness (Worldwatch Institute 2008).

7 Sustainable Development as a Governance Challenge

This background suggests that the core challenge to science of supporting sustainability transition is not primarily a technical or a technological challenge of increasing eco-efficiency *per se*, albeit that this is one of several important components of an overall approach to delivering more sustainable development. Rather, the core challenge is one of governance of sustainability transitions. The top-down need is to ensure over the longer-term that the market and globalisation processes that are the dominant mechanisms of coordination at the global scale are reformed gradually to harness their powerful forces to the achievement of sustainability targets: to ensure that the basic needs of all are met; to stimulate savings and to marshal these into eco-investments of different forms; and to direct achieved improvements in eco-efficiency toward reducing the absolute metabolic throughput of the global economy. There are many candidate macro-scale market reforms that could help here: internationally agreeing and implementing effective planetary safety standards; creating markets for ecosystem services; full cost pricing; and extending producer liabilities on goods entering trade, for example.

But there are important pragmatic considerations to take into account concerning the likelihood and feasibility of introducing different kinds of policy interventions and at different levels and the pace at which interventions can be introduced. Changes in macro-scale market conditions will most likely be introduced only gradually and through phased interventions. Interventions that address particular issues or sectors or are generated and implemented at the spatial scale of particular countries or blocs are likely to be more feasible in the short term. But even modest policy interventions – if well chosen, well designed and well targeted – could critically change the framing conditions for lower-level innovations and work synergistically alongside other (non-policy) sources of change to provide a continually-changing innovation context that opens up new degrees of freedom, new opportunities, and scope for 'clumsy' and 'context-specific' solutions to emerge from bottom-up.

The twin problems of environmental change and poverty are upon us here and now and they call for action at lower levels of scale where the problems are being felt. This reinforces the point just made that there is an important new role for

science in supporting local communities in improving their own situation in respect to their own targets and goals through actions they are able to take themselves in their own contexts of living and operating, taking advantage wherever possible of opportunities created by the higher-level dynamics in regulatory and market frameworks. Important progress is being made already in some policy areas that impinge significantly on market conditions and contexts. The politics of climate change, for example, and associated innovations, such as REDD (Reducing Emissions from Deforestation and Forest Degradation), are increasing the scope for creative and innovative bottom-up approaches to emerge in many Asian, African and Latin American countries. Such initiatives will shortly be reinforced by others developed to support implementation of the Convention on Biological Diversity. There is therefore scope emerging for a creative new co-evolution between top-down innovations in framing conditions and bottom-up innovations in ways that ecosystems are exploited at lower levels of scale. The more bottom-up sustainability initiatives that emerge and the more successful these are the greater become the chances of reinforcing and extending top-down changes in framing conditions and vice-versa.

8 Case Histories from Latin America

Against this backdrop it is useful to review a small number of case histories of bottom-up innovations – in this case chosen from Latin America – to see what lessons and insights they reveal into the governance challenges of sustainable development and how these have been and are being met, including with the help of sustainability scientists. This is important especially to provide inspiration and existence proof that communities facing threats to their livelihoods and security, including environmental change threats, can come together to construct context-specific local solutions that are robust, resilient, fulfilling and equitable and that help immunise them from powerful macro-scale forces that are beyond their immediate control. Such local context-specific solutions have emerged in some instances spontaneously and in other cases have been facilitated or reinforced by policy and market reforms associated with new international policy regimes.

Our first case history concerns a community-based forest governance model that has been developed in the Lachua region of Guatemala. Since 2005 the local community has obtained payments under a PES scheme to protect 3,500 ha of forests and to reforest 2,000 ha of degraded forest areas. Decision making and the management of PES receipts are the responsibilities of democratically-elected community representatives who also develop internal mechanisms to maximize benefits and guarantee an efficient and equitable re-distribution of funds among community members. Parts of the PES receipts are used to financially underpin other sustainable production initiatives, to support a capacity-building programme, and to provide sources of micro-funding. These are aimed at combating local poverty, but also at rebuilding social capital that was seriously damaged in the

course of a long civil war. The Lachua community is now moving to access new funding through REDDS and a Forest Incentives Program, PINFOR. Its experience is serving as a model and a pilot for a national 'REDD- Readiness' programme throughout Guatemala.

Our second case history concerns the Río Plátano Biosphere Reserve located in the Moskitia of Honduras. The Río Plátano area faced strong ecosystem degradation and biodiversity loss owing to unsustainable forestry practices and overhunting. These practices were linked to poverty and to conflicts and competition between different ethnic subgroups. To address these challenges local communities came together to agree upon alternative ways of exploiting their shared ecosystems by producing non-timber forest products, including cocoa, ornamental plants, medicines, and ojon oil, which is used for cosmetics. Of special interest is the community-based governance model around ojon oil production and trade. Production is carried out on collective land. The production system relies on an endemic tree species, *Bactris balanoides*, and uses traditional knowledge about ways to extract oil from the tree. This tree species is highly resistant to hurricanes, so this regime of exploitation is also more robust in the face of climate change. The arrangement generates over $1.3 million annually in sales of ojon oil to cosmetics manufacturers. Receipts are distributed among three indigenous federations, two municipalities, and a range of support organizations in the territory, including a local NGO.

Our third case history concerns the Communal Reserve of Tamshiyacu Tahuayo in Perú, an area of fertile upland forest between the Amazon and Yavari rivers on the border of Brazil. The Reserve is now recognised officially and it has been renamed and extended so that it now covers more than 400,000 ha, but it was constituted originally by the actions of a community organization. Local hunters worried by the decline of wildlife and degradation of their forest ecosystem established a long-term alliance with scientists linked to the Wildlife Conservation Society. They jointly engaged in basic research and in the development of management plans for sustainable hunting. This led to the declaration of a communally-managed protected area and to new economic initiatives for eco-tourism. A newly-added activity is carbon sequestration.

Our fourth case concerns a group of 5,000 small coffee growers who have territorial control over the upper watersheds of the Inambari and Tambopata rivers in the Peruvian Amazon. Facing a decline of land productivity, environmental watershed degradation, and low profits from traditional coffee production, the farmers formed a cooperative – the Coffee-grower Cooperative Central of the Sandia Valleys (CECOVASA). At that time coffee growing in the area was focused by competition among growers on maximising the quantity of coffee produced and lowering the economic production costs to individual growers, a regime that contributed to overproduction while also damaging soils and surrounding vegetation and habitat. In 1998, with the help of an international conservation NGO, CECOVASA developed an ambitious programme of farm conversion to shade-grown, organic coffee of high quality and value. The switch away from intensive production has been highly successful. It has delivered higher and more-stable

incomes and enabled the region and its growers to develop a reputation in a distinct market segment. CECOVASA has won national and international quality awards for its coffee and for production methods that sustain the ecosystem and the underlying asset base for future production. CECOVASA now has ambitions to extend lessons from its experiences to create a coordinated community of cooperatives able to deliver integrated environmental management of the Tambopata river basin at the full watershed scale, including programmes of land restoration, reforestation, and the development of PES schemes.

Our fifth case is an initiative that is being carried forward jointly by two community-based governance organizations, the Akumal Ecological Centre (CEA) and the Union de Vecinos Akumal (UVA) in association with the University of Quintana Roo in Mexico. Prompted by concerns for increasing risks of extreme weather events – especially hurricanes – arising from climate change, a Climate Change Commission has been established in Quintana Roo and a Climate Change Action Plan has been drafted by the Mexican Government with technical support from a regional University. Adaptations to climate change are being developed in association with two local community-based governance organisations, both of which, in very different ways, are committed to better environmental governance and are themselves closely linked to outside organisations offering scientific expertise and advice. Both of these are associated with the Akumal ecological and tourist enclave located 80 km south of Cancun. CEA represents the permanent resident-tourists and UVA represents local workers who service the complex. Despite evident differences in wealth and incomes, both parties have a shared interest in sustaining the pristine coastal, coral and mangrove ecosystems around the enclave, from which they both benefit, and in finding effective responses to environmental challenges, including climate change. Historically, CEA has monitored the impact of tourist and other developments on regional ecosystems. UVA has meanwhile fought to establish workers' entitlements to land and basic services. Both organizations have now extended their mandates and, supported by sustainability scientists, are working together to develop joint responses to climate change in an action that draws both on ecologies of poverty and ecologies of wealth.

Our last case history concerns the Maquipucuna Foundation and the Choco Andes Conservation Corridor in Ecuador. The Maquipucuna Foundation has had a major influence not only on the sustainable governance of the local ecosystems that it helps manage, but on changing understandings and attitudes to conservation in Ecuador as a whole. The Foundation has raised the profile of the Ecuadorian cloud forest and changed the earlier mindset that conservation represents a loss of economic opportunity and sovereignty. Its first initiative was to establish a 6,000 ha reserve. This provides habitat for around 2,000 vascular plant species and 376 bird species and it supports ecotourism, which is now a main source of income for thousand of families in the region. Its next major initiative was to develop a conservation corridor that provides altitudinal connectivity from the mountains to the sea and regimes for its sustainable exploitation. A regime that incorporates shade-grown cacao in the lowland areas and shade-grown coffee in the highlands is generating good incomes while simultaneously supporting habitat connectivity.

The most recent accomplishment has been to help secure property rights over 44,000 ha for the Esmeraldas afro-ecuadorian community, which is the outcome of a decades-long struggle.

9 Reflections and Final Remarks

Sustainable development is a paradox. On the one hand there is a need for a radical overhaul and restructuring of our current social-ecological systems, which demands change. On the other hand there is a need to secure social, economic, financial and political stability on a continuing basis. To reconcile these conflicting requirements calls for a careful moderation of the pace of change and care in choosing transition pathways so that these are smooth and avoid catastrophic discontinuities and disruptions.[4]

The overall need is to achieve radical change in the global social-ecological system through orderly and evolutionary change processes based on incremental steps that gradually weaken the structures and mechanisms that contribute to unsustainability and replace these with more sustainable structures and mechanisms. This calls for new kinds of multi-level change processes that involve a dynamic interplay and modulation between gradually-introduced top-down changes in framing conditions, which increase local autonomy and give strategic steer, and sets of context-specific innovations that are developed bottom-up and in patchwork fashion, which are enabled in part by such top-down innovations. Bottom-up solutions developed in this way should contribute to improving local sustainability and also reinforce the initial top-down changes and support their further extension.

Our case histories illustrate that this is arising now, for example, through the creation of new markets for ecosystem services. They illustrate also that effective, cooperative and sustainable solutions can come about through self-organisation at the local scale in response to challenges faced and to opportunities that changing frameworks, such as PES opportunities, create. Conditions conducive to such self organisation have been identified already: predictability of higher-level system dynamics, leadership, social capital, common understanding of the social-ecological system and autonomy to make own operational rules, among others (Ostrom 2007). Our case histories illustrate that access to scientific support, both of a technical

[4]This goes some way to explaining why there are no panaceas to the sustainable management of natural resources and ecosystems. Resource degradation commonly has multiple causes rooted in complex interactions between the natural and social components of social-ecological systems. Social-ecological systems are complex, multi-level systems that are not amenable to ‘one-size-fits-all’, ‘silver-bullet’, or ‘quick-fix’ solutions. One-dimensional solutions, unidirectional solutions (top-down or bottom-up), and generalised approaches are all inappropriate. By contrast, sets of carefully chosen changes introduced top-down (especially those that affect markets, which are our most powerful mechanisms of global coordination) may combine synergistically to provide new scope and viability for alternative and more sustainable solutions at local scale to emerge bottom-up.

nature and, more especially, to facilitate processes of social learning, issue reframing, conflict resolution and governance is likely to be another such condition.

The case histories provide inspiration and existence proof that in the face of threats to their livelihoods and security, communities can come together to take advantage even of small windows of opportunity for positive change, including opportunities created around the politics of climate change and biodiversity conservation.[5] They show that, far from acting as 'constraints' on development, international responses to global concerns for climate change, habitat destruction and biodiversity loss in the form of establishing safety boundaries, can increase the degrees of freedom open to local communities over their choices for managing local common pool resources more sustainably, for example by financially or otherwise underpinning sustainable livelihood and sustainable ecosystem exploitation options with payments for ecosystem services (PES).

They also reveal how the concept and politics of climate change can create mobility in forms of governing and social values, which in turn can create opportunity and scope for transformation in the handling of transition to sustainability. Substantial direct non-material benefits to the concerned communities and their members can also be achieved through the governance processes, for example through greater and more inclusive involvement of community members in decision making and by community members taking greater control over their own lives, resources, environment and destiny. Such processes provide routes not only for empowering marginalised groups, but also for satisfying important social and psychological needs, which adds directly to the wellbeing and welfare of communities and individuals. For example, they may serve to win respect for and raise the self-esteem of individuals and groups, such as the poor, ethnic or religious minorities, women and children, who might otherwise be overlooked or excluded, but whose involvement is critical for sustainability.

The challenge of implementing a strategy based around sustainability transitions of the kind just described implies new, additional and different roles for science and scientists in facilitating mediation and modulation between top-down and bottom-up innovations. Especially it suggests a key role in supporting processes of community-based governance of ecosystems and in helping communities to develop and implement bottom-up initiatives that take advantage of opportunities as these arise. These are roles that even go beyond applied problem solving to involve also nurturing mobility in forms of governance and in social values. They are not easy

[5]The case histories describe instances where communities facing threats to common-pool ecosystems and environmental resources upon which they depend have overcome destructive rivalries and have come together to cooperate in developing new and more sustainable regimes of ecosystem management. A shared understanding of the nature and significance of the threats faced is an important factor in the emergence of new governance arrangements and of alternative ways to use and conserve ecosystems. The alternative regimes often involve new management rules, which restrain certain practices. Arrangements for cost and benefit sharing are often integral elements of the governance approach and may include mechanisms for compensating those who lose from changes in management regime and for ensuring an equitable distribution of benefits from the new regimes.

roles for scientists to play or ones that fit well with scientific cultures and conventions or with prevailing organisational and institutional arrangements in science. However, it is through these roles – played out locally in situations and contexts throughout the world over the coming years as communities everywhere come to search for new solutions to the ways they meet their needs and take a greater control over their own destinies and environment – that scientists will probably have most impact on the prospects for sustainable development. Important theoretical concepts developed recently in the emerging field of Transition Theory (Grin et al. 2010), Sustainability Assessment (e.g. Weaver and Rotmans 2006; Rotmans et al. 2008) and Ecosystems Approaches provide tools and methods for scientists to apply in the task.[6]

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[6]Methodologically, Integrated Sustainability Assessment (ISA) combines three elements: an integrated systems analysis, which seeks to secure broad scope for the assessment; a multi-level and agent-based analytical approach, which seeks to understand multi-level processes that can lead to structural change and transition; and a cyclical, participatory process architecture, which seeks to promote social learning among stakeholders through an empowering dialogue, experimentation and transformative capacity building. ISA offers an approach for stimulating the social and institutional processes that contribute to emergent solutions.