Climate Change Research: Evaluation and Policy Implications
S. Zwerver, R.S.A.R. van Rompaey, M.T.J. Kok and M.M. Berk, (Eds.)

Sustainable Development and Climate Change

R.K. Turner

Centre for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia, Norwich and University College London, United Kingdom

Abstract

Sustainability is defined in terms of four overlapping positions, ranging from very weak to very strong sustainability. The core idea is of a non-declining capital stock (including natural capital) over generational time. Weak sustainability positions emphasise capital substitution possibilities and the power of technical process to mitigate resource depletion and pollution problems. Climate change and its associated risks and strong uncertainty are characterised by features which favour a strong sustainability approach incorporating the precautionary principle. Strong sustainability positions recognise constraints on substitution processes and incorporate ethical concerns such as intergenerational equity as a moral duty. Cost-benefit analysis is moderated via safe minimum standards which set GHGs concentrations and emissions abatement targets.

Introduction: Sustainable Development Concept

Economists define sustainable development in terms of non-decreasing levels of utility, or income per capita, or real consumption per capita over time. In broad terms it involves providing a bequest from the current generation to the next of an amount and quality of wealth which is at least equal to that inherited by the current generation. This requires a non-declining capital stock over time and is consistent with the intergenerational equity criterion. The most publicised definition of sustainable development credited to the World Commission on Environment and Development also included an intragenerational equity criterion (WCED, 1987). Sustainability therefore requires a development process that allows for an increase in the wellbeing of the current generation (with particular emphasis on the welfare of the poorest members of society), while simultaneously avoiding uncompensated and 'significant' costs (including environmental damage costs) on future generations. Such a cost liability would reduce the 'opportunities' for future generations to achieve a comparable level of well-being (Pearce, Barbier and Markandya, 1990). The sustainability approach therefore is based on a long-term perspective, it incorporates an equity as well as an efficiency criterion, and it may also emphasise the need to maintain a 'healthy' global ecological system (Costanza et al., 1992).

A spectrum of overlapping sustainability positions (from very 'weak' to very 'strong') can be distinguished, see Figure 1 (Turner, 1993). Weak sustainability requires the maintenance of the total capital stock - composed of

FIGURE 1 SPECTRUM OF OVERLAPPING SUSTAINABILITY POSITIONS

VWS — WS — SS — VSS

VWS – WS

- efficiency criterion
- neoclassical economics paradigm
- rational individuals as consumers
- utilitarian individualism and preference value
- market-based valuation
- anthropocentric instrumental value
- total economic value concept (private values)
- infinite capital substitution possibilities and technical progress

WS – SS

- efficiency and equity criteria
- systems perspective: ecosystem 'health' and 'integrity'
- intergenerational equity duty
- anthropocentric instrumental value
- anthropocentric intrinsic value
- nonanthropocentric instrumental value
- Aggregated private values ≠ social value of ecosystems
- Primary and Secondary Values in Nature
- 'Critical' Natural Capital Constraints
- Strong uncertainty and irreversibilities
- Safe Minimum Standards Approach

SS – VSS

- bioethical criteria and constraints
- nonanthropocentric intrinsic value
- transformative value in nature
- nonhuman rights and interests

VWS = very weak sustainability
WS = weak sustainability
SS = strong sustainability
VSS = very strong sustainability

Source: Adapted from Turner ed. (1993) ch. 1

K_m (manufactured or reproducible capital); K_h (human capital, or the stock of knowledge and skills); K_n (natural capital: exhaustible and renewable resources, together with environmental structures, functions and services) - through time with the implicit assumption of infinite substitution possibilities between all forms of capital. The Hartwick Rule (Hartwick, 1978) is also used to buttress the weak sustainability position by regulating the intergenerational capital bequests. The rule lays down that the rent obtained from the exploitation of the natural capital stock by the current generation, should be reinvested in the form of reproducible capital which forms the future generations' inheritance. This inheritance transfer should be at a sufficient level to guarantee non-declining real consumption (well-being) through time.

The implicit capital substitutability assumption underpins the further argument that extensive scope exists over time for the decoupling of economic activity and environmental impact. The decoupling process is mediated by technical progress and innovation. While total decoupling is not possible, and with the important exception of cumulative pollution, society's use of resources can be made more efficient over time (i.e. the amount of resources used per unit of GNP goes down faster than GNP goes up and the aggregate environmental impact falls). From the weak sustainability perspective a key sustainability requirement will be increased effective research and development, i.e. new knowledge properly embodied in people, technology and institutions.

From the strong sustainability perspective some elements of the natural capital stock cannot be substituted for (except on a very limited basis) by man-made capital and therefore there is a concern to avoid irreversible losses of environmental assets. Some of the functions and services of ecosystems in combination with the abiotic environment are essential to human survival, they are life-support services (e.g. biogeochemical cycles) and cannot be replaced. Other multi-functional ecological assets are at least essential to human wellbeing if not exactly essential for human survival (e.g. landscape, space and relative peace and quiet). We might therefore designate those ecological assets which are essential in either sense as being 'critical natural capital'. Supporters of the "deep ecology " [VSS] position argue for a particular type of non-substitutability based on an ethical rejection of the trade-off between man-made and natural capital. The strong sustainability rule therefore requires that we at least protect critical natural capital and ensure that it is part of the capital bequest.

The combination of the risk of irreversible environmental losses and a high degree of uncertainty surrounding past rates and future trends in resource degradation and loss, as well as the full structural and functional value of ecosystems (Gren, Folke, Turner and Bateman, 1994), leads strong sustainability advocates to adopt the precautionary principle. Conservation of natural capital and the application of a safe-minimum standards (Bishop, 1993) approach are therefore important components of a strong sustainability strategy. This message is that environmental degradation and loss of natural resources represent one of the main ways in which today's generation is creating uncompensated future costs. Hence restoration and conservation of natural resources and the environment is crucial to achieving sustainable development.

A number of sustainability rules (which fall some way short of a blueprint) for the sustainable utilisation of the natural capital stock can be outlined:

I) Market and policy intervention failures related to resource pricing and property rights should be corrected.

II) The regenerative capacity of renewable natural capital should be maintained, i.e. harvesting rates should not exceed regeneration rates; and cumulative pollution which could threaten waste assimilation capacities and life-support systems should be wherever feasible avoided.

III) Technological changes should be steered via an indicative planning system such that switches from non-renewable natural capital to renewable natural capital are fostered; and efficiency-increasing technical progress should dominate throughput-increasing technology.

IV) Resources should, wherever possible, be exploited, but at a rate equal to the creation of substitutes (including recycling).

V) The overall scale of economic activity must be limited so that it remains within the carrying capacity of the remaining natural capital. Given the uncertainties present, a precautionary approach should be adopted with a built-in safety margin.

Figure 2 summarises some of the measures and enabling policy instruments that would be involved in any application of a very weak sustainability (VWS) through to a very strong sustainability (VSS) strategy (Turner, 1993).

From our review of sustainability, the emphasis on equity and social issues in sustainability as well as on the physical constraints is important. For development to be sustainable it must incorporate (under the strong sustainability view) non-depletion of natural capital; both intergenerational and intragenerational equity principles; and in the latter context must be capable of providing sustainable livelihoods to those whose livelihoods are primarily natural resource dependent. Agenda 21 sets out principles for sustainable development without advocating any explicit definition of sustainability and with a tendency for focusing on global issues which may not be of greatest concern to those poorest sections of the world. The implicit definition of sustainability within Agenda 21 however would seem to be closely related to the concept of strong sustainability discussed above, though the lack of operational details and the prevailing obstacles to change mean that implementation of such an agenda represents a very formidable task.

In the context of climate change the sustainability concept would favour the adoption of a general response strategy that was based on the following ethical arguments:

there is an obligation to avoid harm to future generations, either in an absolute sense, or so long as the avoidance measures themselves do not impose unacceptable cost on society;

Figure 2 Sustainability Practice

Sustainability Mode (overlapping categories)	Management Strategy (as applied to projects policy or course of action)	Policy Instruments (most favoured)		
		Pollution Control and Waste Management	Raw Materials Policy	Conservation and Amenity Management
VWS	**Conventional Cost-Benefit Approach:** Correction of market and intervention failures via efficiency pricing; potential Pareto criterion (hypothetical compensation); consumer sovereignty; infinite substitution	e.g. pollution taxes, elimination of subsidies, imposition of property rights		
WS	**Modified Cost-Benefit Approach:** extended application of monetary valuation methods; actual compensation, shadow projects etc; systems approach, 'weak' version of safe-minimum standard	e.g. pollution taxes, permits, deposit-refunds; ambient targets		
SS	**Fixed Standards Approach:** Precautionary Principle, recognition of the full value of natural capital; constant natural capital rule; 'strong' version of safe minimum standard	e.g. Ambient standards; conservation zoning; process technology-based effluent standards; permits; severance taxes (i.e. taxes on resource extraction); assurance bonds (a sort of market-based insurance fund to mitigate environmental damage impacts)		
VSS	**Abandonment of Cost-Benefit Analysis:** or severely constrained cost-effectiveness analysis; bioethics (i.e. an acceptance of the rights and interests of non-human species which then constraints human activity on moral grounds, e.g. the loss of tropical forests is in some circumstances morally wrong)	standards and regulations; birth licences		

Source: Turner (1993)

the avoidance of harm to future generations is important because the future has no power to influence decisions taken now which may cause them harm; and

current generations have moral obligations to future generations (either via overlapping generations or via the acceptance of interests/rights for future people).

Climate change may strain an economy's capacity to achieve sustainable development by imposing unpredictable and significant damage, damage mitigation and adaptation costs. Resource investment and development planning may then be badly disrupted, pushing the sustainability goal further into the future. Developing economies will be faced with disproportionality severe dislocation costs because of their 'vulnerable' socio-economic systems and supporting ecological systems. Climate change is only one component of global environmental change (i.e. a complex flux of factors - population growth, increasing urbanisation, increasing industrialisation and intensification of agriculture, increasing rate of economic growth and international economic interdependency, the globalisation of information transfer and communications and an increasing rate of attitudinal and lifestyle changes - the impacts of which can manifest themselves at a number of different spatial and temporal scales). Many developing countries, and to a lesser extent some regions (e.g. coastal zones) of developed countries, are already under heavy environmental pressure and potential climate change impacts on, in particular, agricultural sectors and coastal zone resources will further exacerbate their developmental problems. Climate risk is therefore very much an equity issue because the cost of risk-bearing is not evenly distributed across societies, and more significantly across countries. Developing countries will face an especially high risk-bearing cost burden. We now turn to a closer examination of climate change risk and its implications for sustainable development.

Climate Change Risk

Climate risk and other Global Environmental Change risks are shrouded by strong uncertainty and this is especially so at the regional level. The global scope of the potential changes means that there is collective risk which affects very large numbers of people. These risks are not statistically independent and the effectiveness of risk "pooling" is reduced. They are also endogenous risks in the sense that the global systems changes are being driven by human economic activity, because of its sheer 'scale' (Chichilnisky and Heal, 1993). The economy and the environment are jointly determined systems and the overall scale of economic activity is now very significant. Climate change impacts are potentially therefore part of a wider set of impacts and consequences. There is also a degree of permanent unpredictability present because the dynamics of the jointly determined system (coevolutionary process) are characterised by discontinuous change around critical threshold values both for biotic and abiotic resources, and for ecosystems functions. The stability of the jointly determined economy-environment systems depends less on the stability of individual resources, than on the resilience of the system, i.e. the ability of the system to maintain its self-organisation in the face of stress and shock. Unfortunately even if the critical threshold values could be discovered, neither the transition time to a new system state, nor the form of the new system state could be predicted. It is now a matter of some debate in the context of climate states whether the most 'natural' behaviour to be expected is a gradual warming trend process, or an abrupt phase change, as one climate region gives way to a new one (either globally or regionally).

The characteristics of climate and related risks and the pressure of strong uncertainty provide a compelling rationale for the deployment of strong sustainability/precautionary instruments in ecological economic systems. The existence of possible threshold effects involving irreversible loss of potential productivity, and the failure of markets to signal the nearness of such thresholds, both imply the need for instruments that maintain economic activity and its pollution and waste generation consequences within appropriate bounds. The economic perspective, in principle, suggests the following analytical sequence for GHGs abatement and mitigation of other global environmental change effects - a general acceptance and application of extended cost-benefit analysis; recognition and quantification wherever feasible of environmental risks; deployment of the precautionary approach via safe minimum standards (subject to their social opportunity costs) in the presence of strong uncertainty; deployment of a portfolio of enabling policy instruments to meet the chosen GHGs concentrations abatement targets and other sustainability goals.

Climate Change Decision-Making Strategies

Greenhouse gases (GHGs) induced climate change poses a multifaceted challenge which has to be addressed via a collective decision-making framework operating at both the national and international levels. The decision-making contexts are characterised by 'strong' uncertainty and irreversibility and therefore favour the adoption of more, rather than less, risk averse strategies. A priori, a strong sustainability approach would seem therefore to be appropriate since it recommends the avoidance of those options which may generate the worst outcomes ('unacceptable' cost burdens) and encompasses the precautionary principle. What is and what is not an acceptable cost, from the strong sustainability, perspective is only partly measured by reference to individuals' preferences (conventional economics approach). Individuals may not be well informed about climate risk and expert opinion is constrained by strong uncertainty. Further, human preferences may not fully capture intrinsic values in nature - see Figure 3.

In the market place, a product's value is encapsulated in its market price which in turn is determined in part by consumers' willingness-to-pay. But environmental resources often have no price tag and information is lacking concerning their 'true' value and significance. Many of these environmental assets are also public goods and this is another characteristic that makes it difficult for markets to evolve in such assets. To make the comparisons of environmental and other costs and benefits, within cost-benefit analysis, economists have therefore to impute a value for non-market environmental assets. A range of valuation methods and techniques have been deployed in order to estimate the value of various components of the environment.

Environmental economists have developed a terminology of valuation which distinguishes between individual (private) use value (direct and indirect use of the environment), option value, quasi-option value, bequest and existence (non-use) value. Debate continues over the precise boundaries between these different components of total economic value. The social value of environmental resources is then simply the aggregation of private values.

However, ecological economic research findings indicate that the social value of environmental resources committed to some use may not be equivalent to the aggregate private value of the same resources in any given system, because of the following factors:

1. The full complexity and coverage of the underpinning 'life support' functions of healthy evolving ecosystems is currently not precisely known in scientific terms. A number of indirect use values within systems therefore remain to be rediscovered and valued.

Figure 3 A General Value Typology

1. Anthropocentric Instrumental Value

This is equivalent to

"Total economic value" = use + non-use value.

= DUV	+	IUV	-+	OV	+	QOV	+	BV	+	EV
[direct use value]		[indirect use value]		[option value]	·	[quasi-option value		[bequest value]		[existence value]

The non-use category is bounded by the **existence value** concept which has been the subject of much debate. Existence value may therefore encompass some or all of the following motivations:

interpersonal altruism, resource conservation to ensure availability for others; vicarious use value linked to self-interested altruism and the "warm glow" effect of purchased moral satisfaction;

intergenerational altruism (**bequest** motivation and value), resource conservation to ensure availability for future generations;

stewardship motivation, human responsibilities for resource conservation on behalf of all nature;

"**Q-altruism**", motivation based on the belief that non-human resources have rights and/or interests and as far as possible should be left undisturbed.

If existence is defined to include stewardship and "Q-altruism" then it will overlap into the next value category outlined below

2. Anthropocentric Intrinsic Value

This value category is linked to "Weak anthropocentrism" in a subjectivist sense of the term value. It could be culturally dependent. The value attribution is to entities which have a "sake" or "goods of their own", and instrumentally use other parts of nature for their own intrinsic ends..." It remains an anthropocentrically related concept because it is still a human valuer that is ascribing intrinsic value to non-human nature ("Q-altruism").

3. Non-Anthropocentric Instrumental Value

In this value category entities are assumed to have sakes or goods of their own independent of human interests. It also encompasses the good of collective entities, e.g. ecosystems, in a way that is not irreducible to that of its members.

But this category may not demand moral considerability as far as humans are concerned.

4. Non-Anthropocentric Intrinsic Values

This value category is viewed in an objective value sense, i.e. "inherent worth" in nature, the value that an object possesses independently of the valuation of valuers. It is a meta-ethical claim, and usually involves the search for constitute rules or trump cards with which to constrain anthropocentric instrumental values and policy.

Source: Adapted from Hargrove (1992)

2. Because the range of use and non-use value that can be instrumentally derived from an ecosystems is contingent on the prior existence of such a healthy and evolving system, there is in a philosophical sense a 'prior value' that could be ascribed to the system itself. Such a value may not, however, be measurable and may not be commensurate with the economic (secondary) values of the system.

3. The continued functioning of a health ecosystem is more than the sum of its individual components. There is a sense in which the operating system yields or possessed 'glue' value, i.e. related to the structure and functioning properties of the system which holds everything together.

4. A healthy ecosystem also contains a redundancy reserve, a pool of latent keystone species and processes which are required for system maintenance in the face of stress and shock.

The adoption of a systems perspective, the recognition of primary ecosystem value (in addition to secondary value related to components of the system) and the nature of much environmental risk, i.e. high cost, low probability risks, emphasise the need for policy instruments that safeguard the range of options to future generations. Such precautionary instruments ensure that irrespective of the actual outcome of current activity, the next generation is left with an equivalent resource endowment (allowing for some trading between different forms of capital-physical capital, human capital and natural capital) and opportunities for economic development. These are commonly identified as sustainability constraints, e.g. safe minimum standards. Uncertainty about system boundaries and the effects of scale and thresholds underline the value of a precautionary approach, and many sustainability instruments have the property that they are precautionary. Sustainability requires each generation to maintain the self-organising systems that provide the context for all human activity and therefore possess 'primary' value. This does not imply that all assets should be preserved. Rather it implies conservation of opportunity. Thus one criterion, for example, for decision-making under 'strong' uncertainty is the 'maximim' criterion (i.e. minimise the worst outcome strategy). This is also complementary to the Rawlsian equity criterion (i.e. maximise the conditions of the least well off).

On the other hand, since the uncertainties are so great and potential mitigation costs are so high, a better strategy might be to 'wait and see' and not to adopt any extensive policy interventions. As scientific, economic and technological data cross some of the uncertainties may diminish and we will be better able to discern and quantify the GHGs abatement cost and damage cost functions. Policymaking could then be aided by the application of the cost-benefit method and techniques. Such an approach would be more in line with the 'weak' sustainability perspective.

For some commentators the 'wait and see/business-as-usual' stance is attractive because they argue that if the forecast of a gradual trend rate of temperature rise (+0.3k per decade) is accurate (Houghton et al., 1990), then the global temperature signal will be discernible sometime between 2010 and 2020.

Policymakers therefore ought to defer any significant GHGs emission abatement measures to the next generation, and take out 'partial cover' by encouraging insurance schemes applicable to individuals and nations (e.g. Alliance of Small Island States International Insurance Pool proposal). Critics have countered that the mere existence of strong uncertainty cannot justify a no policy response option. The potential climate-induced damage costs could be very high, and in any case are only one possible element in the aggregate global environmental change impacts, many of which have already put heavy pressure on ecosystem resilience and adaptation capacities. The futures' 'opportunities' set is therefore being threatened, especially as GHG impacts may be irreversible. Whether or not future generations do possess moral rights or interests, most people would support the view that the present's 'coefficient of concern' for the future is not zero. Finally, a range of policy options are either 'no regret' negative net cost options, or are moderate cost options because once implemented they carry with them secondary benefits in addition to avoided climatic change damages.

The decision-making context and process are complex because uncertainty and irreversibility characteristics are compounded by the existence of a range of conflicting decision criteria, e.g. economic efficiency, intragenerational/ intergenerational equity, sustainability and precaution. The process probably has to be both hierarchical and sequential. Taking the weak sustainability position, we might assume that given moderate rates of technical progress (1 to 2% per annum) and actual global warming adaptation costs of up to 3% of GNP, future generations will be substantially better off than the current generation. So if the future benefits outweigh the present abatement costs, the future should pay those costs. But recall the weak sustainability capital substitution axiom, which in this context assumes that atmospheric capital is substitutable by man-made capital. If no such extensive substitution is possible then delaying GHG abatement measures in favour of providing a capital bequest (and investing is knowledge) for future generations cannot be justified.

Alternatively, taking the strong sustainability position, possible significant future damage costs and irreversible impacts suggest that the future may be made worse off than the present. The passing on of a 'net liabilities' bequest to the future is morally questionable. Therefore a global level GHGs concentrations/emissions abatement target and interregional allocations need to be exogeneously set, guided by the precautionary principle. Once the commitments have been made then the search should be for cost-effective enabling measures, which should be adopted sequentially - 'no regret' energy conservation and efficiency improvement measures first, followed by fuel switching and other measures requiring longer lead times and significant capital investments.

Weak Versus Strong Sustainability Policy Option Portfolios

In principle, the full set of climate change response measures include the following:

(I) science-based research to reduce climate change and impact uncertainties;

(II) technological research focused on more cost-effective GHGs mitigation measures (energy conservation and efficiency measures etc);

(III) reversal of policies which in the past have encouraged the inefficient use of resources and waste sinks (i.e. correction of market and intervention 'failures');

(IV) joint implementation, technology transfer and other forms of international cooperation to limit climate change;

(V) measures to reduce GHGs emissions and/or to increase sequestration of GHGs;

(VI) measures to enhance adaptation capacities of both socio-economic and natural systems facing the consequences of climate change;

(VII) insurance schemes to hedge against climate risk and the costs of adaptation;

(VIII) policy interventions directed at the main drivers of global environmental change (such as population growth) and its related pressures.

The different sustainability perspectives encourage the adoption of different policy option portfolio configurations. A weak sustainability strategy would seek to promote a portfolio based on measures (I), (II), (III) and (VII). It would be a more reactive rather than a proactive strategy and would lay great stress on the ability of research and development to reduce uncertainty and promote efficient resource usage. Cost-benefit thinking and analysis would be used as an important aid to decision-making.

A strong sustainability strategy would seek to implement a more proactive and a more comprehensive policy portfolio including all the measures (I) to (VIII) in the list above. It would lay stress on the need for a precautionary approach and would recognise an obligation to future generations, not to pass on net liabilities. It would further seek to incorporate climate change impacts within a more general recognition of the GEC 'scale' problem. In this context integrated resource management strategies would be highlighted (e.g. integrated coastal zone management). Cost-benefit analysis would be constrained by the precautionary principle via a safe-minimum standards (SMS) approach. The latter would be applied in an absolute sense (regardless of costs) when and if 'critical' natural capital assets were identified as being under threat; and more generally in a relative sense depending on the social acceptability of the SMS's own cost implications.

References

1 R. Bishop, Economic efficiency, sustainability and biodiversity. Ambio 22 (1993) 69-73.

2 G. Chichilnisky and G. Heal, Global environmental risks. Journal of Economic Perspectives 7 (1993) 65-86.

3 R. Costanza et al., Ecosystem Health: New Goals for Environmental Management, Island Press, Washington, 1992.

4 I-M. Gren, C. Folke, R.K. Turner and I. Bateman, Primary and secondary values of wetland ecosystems. Environmental and Resource Economics 4 (1994) 55-74.

5 C. Hargrove, Weak anthropocentric intrinsic value. The Monist 75 (1992) 183-207.

6 J. Hartwick, Substitution among exhaustible resources and intergenerational equity. Review of Economic Studies 45 (1978) 347-354.

7 J.T. Houghton et al. (eds), Climate Change: The IPCC Scientific Assessment, Cambridge University Press, Cambridge, 1990.

8 D.W. Pearce, E. Barbier and A. Markandya, Sustainable Economic Develpment, Edward Elgar, Aldershot, 1991.

9 R.K. Turner (ed), Sustainable Environmental Economics and Management, Belhaven Press, London, 1993.

10 World Commission on Environment and Development, Our Common Future, Oxford University Press, Oxford, 1987.