Chapter 18

Indigenous Knowledge and Modern Science as Ways of Knowing and Living Nature: The Contexts and Limits of Biosafety Risk Assessment[1]

BRIAN WYNNE
ESRC CENTRE FOR ECONOMIC AND SOCIAL ASPECTS OF GENOMICS, CESAGEN, LANCASTER UNIVERSITY, UK

> ‘Attempts to draw a strict line between scientific and indigenous knowledge on the basis of method, epistemology, context-dependence or content, it is easy to show, are ultimately untenable’. (Agrawal 2002:293)

Introduction

In the context of the Cartagena Protocol on Biosafety to the UN Convention on Biological Diversity (CBD), the interactions between modern scientific cultures and indigenous cultures, and their ways of knowing nature, have become highly relevant. Indeed, as Hayden (2003a; 2003b; also Greene 2004) has noted, a particular strategic construction of indigenous (and scientific) ways of knowing and practising in relation to nature and biodiversity, is built into the CBD. This is the effective assertion, explained later, that ‘in order to protect nature, first we have to *exploit* it’.[2] Western science has assumed a dual role in this global environmental, commercial, ethical, and political nexus – both as means of commercial exploitation of indigenous knowledge of biodiversity and (some of) its useful properties, and as medium of protection, through recording of loss, risk assessment, and related regulatory knowledge and action. This is the larger context within which the question of the adequate risk assessment of genetically modified (GM) crops, especially when globally exported into developing countries, has to be considered.

Global indigenous peoples have mobilised at the CBD over concerns about threats to their cultures, livelihoods and identities (see e.g. UNEP 2005; Oldham 2007). After a centuries-long history of direct and often violent exploitation, through land-grabs and many other forms of resource expropriation, more recently these threats have increasingly come from interventions performed in the name of *science* as modernisation – deforestation, disruption and chemical exposure in the name of ‘modern’ industrial agriculture, even expulsion from traditional cultural habitats in the name of environmental management (Leach & Mearns 1996).[3] These scientifically rationalised interventions have themselves been increasingly performed through genomics-related interventions, for example in the search for commodifiable plant-genetics properties from indigenous knowledge (Hayden, 2003a; 2003b), the analysis of indigenous human DNA for commercially exploitable insights into disease and disease-resistance (Oldham 2007), and the

[1] The singular terms are used for convenience. I do not intend to suggest that either scientific or indigenous knowledge-culture can be described as singular. The misplaced, if understandable, tendency to homogenise both these heterogeneous categories as if they were unitary ‘systems’ of knowledge or culture, has been critically addressed by, for example, Hobart (1993), though the implication is still suggested in recent works (e.g. Viveiros de Castro 2006), where some fundamental differences between Western modern culture and indigenous cultures are discussed, which inevitably implies an endogenous unity of each even while the author is also well aware of but is suspending other intra-category differences.
[2] As anthropologists have noted, ‘nature’ here has often included indigenous peoples and cultures, as exotic objects for instrumental study – and potential exploitation.
[3] The conflicting parochial cultural bases of modern scientific and indigenous ways of performing nature and society were well-exemplified in Verran’s (2002) participatory study of environmental scientists’ and aboriginal landowners’ land firing practices in Northeast Arnhem Land, Australia.

attempted development of DNA taxonomies of biodiversity in 'the (global) DNA-barcoding of life'.[4]

The global export of GM agricultural science and technology to areas of the world where indigenous cultures exist has not been seen to impact primarily on these cultures themselves. However, in this chapter I highlight three dimensions of these intersections which are relevant to the question of whether prevailing institutionalised Western models of scientific risk assessment are adequate (Winickoff et al. 2005) for assessing the consequences and implications of modern agricultural biotechnologies in developing countries, where most of the world's biodiversity, and cultural diversity are located. These are:
The way in which scientific knowledge not only *informs* policy processes with relevant validated knowledge, but also frames the recognised *meaning* of the public issues. In other words, it presumptively plays a political role of defining what the salient questions are which need such information, and thus also what is to be ignored as a concern.
The ways in which institutionalised versions of scientific rationality, typically preached as 'sound science' in risk assessment arenas, omit and delete significant kinds of uncertainty and contingency, including ignorance. An intellectually rigorous science would attempt to identify, differentiate and logically address rather than confuse these, even if such response would rationally involve more than changes to scientific advice, but would also require institutional changes. This artificial reduction of uncertainties to only those for which (predictive) control can be claimed or at least promised, has the corresponding ethically provocative consequence of externalising unpredicted consequences onto unknown marginal others, in the future or present. Later, I suggest such institutional changes to risk assessment which are also salient to developed world contexts, and have been proposed to, for example, the European Union (EEA 2002; Wynne & Felt 2007).

This intellectually reductionist property of modern science, defined by its instrumental ethic, connects with a third form of intersection. This is that, contrary to prevailing beliefs,[5] modern scientific knowledge is not at all only observing and representing nature (Hacking 1983; Rheinberger 1997; 1999). It is also, as a function of its institutional and epistemological transformations over the 20th century, *intervening* in nature as it observes and represents it. Thus, scientific observation is always in some degree also manipulation of nature. This has increased as science and technology have industrialised and merged into techno-science, and scientific knowledge production has become the servant of – as imagined – endlessly accelerating global economic innovation, when recently it was seen as 'the independent republic of science' (Polanyi 1962), which supposedly 'speaks truth to power'.

Thus, a central point of this outline comparison of some key features of scientific and indigenous knowledge-cultures is not to romanticise the indigenous as the supposedly innocent counterpart to science's ethically-challenged, 'purpose-disoriented' instrumentalism. The point is to use these contrasts and comparisons to throw into perspective some of the aspects of GM agricultural techno-sciences including their 'sound-scientific' risk assessment which would otherwise go unnoticed and taken for granted, by default.

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[4]For example: '[Indigenous Knowledge] is a short-cut to the discovery of new medically or industrially useful compounds' (Farnsworth 1990); 'the exploration of biodiversity [is under way] for commercially valuable genetic resources or materials' (Reid, cited in Moran et al. 2001).
[5]As articulated, for example, by former UK PM Tony Blair, in a speech to the London Royal Society (Blair 2002) 'Science Matters'.

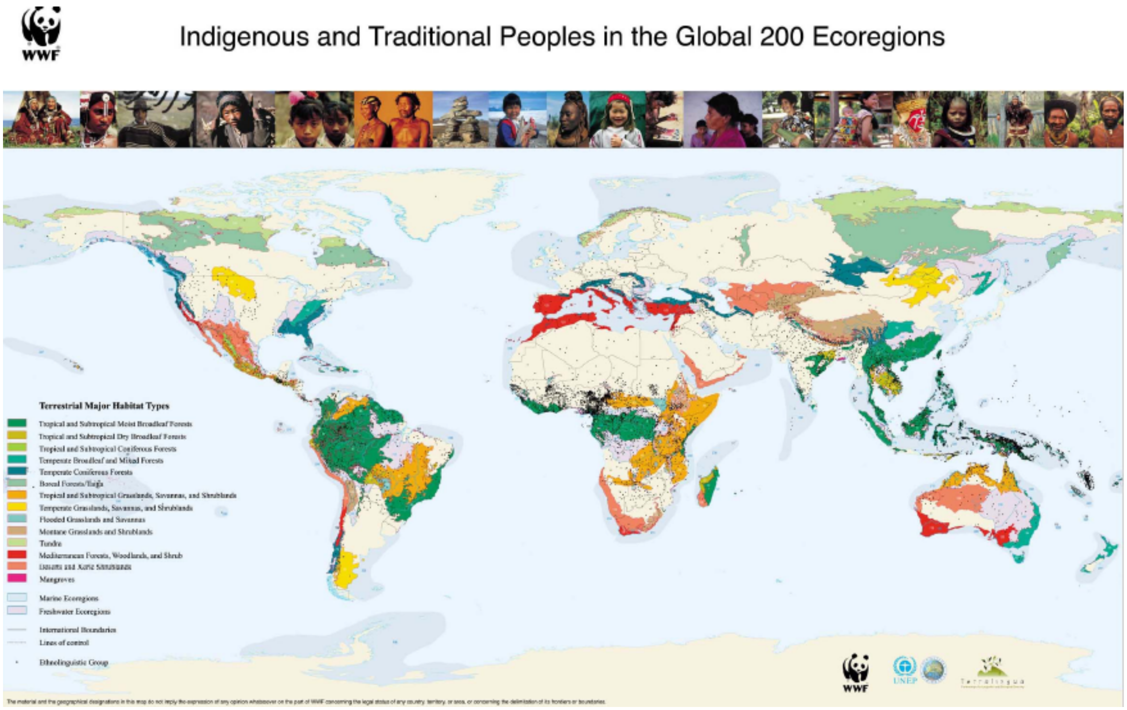

Figure 18.1
The map presented in Fig. 18.1, from WWF-Terralingua, shows the strong global correlation between loci of cultural diversity (measured by numbers of different languages) and biodiversity. To summarise, there are approximately 6000 different spoken languages worldwide, of which 4000–5000 are tribal or indigenous peoples' languages. An estimated 67% of such ethnolinguistic groups are in regions of outstanding international biodiversity and ecological importance (WWF-Terralingua 2000). UNESCO (2002) has stated that 3000 of these living community ethno-linguistic traditions are 'endangered, seriously endangered or dying'. Global biodiversity has also been described as being extinguished before we can even know what we are losing (Royal Society 2004).

Laird and Wynberg describe the global growth of GM or transgenic agricultural biotechnologies as 'escalating at a rate that surpasses that of any new technology ever embraced by the agricultural industry' (UNEP 2005: 19). The global market value of GM seeds and technology fees for 2004 was USD 4.70 billion, and cumulatively since commercialisation began in 1996, USD 24 billion. They have estimated the promised future market value of indigenous biodiversity knowledge for pharmaceuticals alone, leaving aside other imagined products, as USD 60 billion. Although this is promise, thus fiction not fact, it is this promise that drives such fervent global scientific and commercial investment in such knowledge. In this sense it is *material* imagination. Risk assessment alone, however good its scientific basis, cannot be expected to provide more than a part of the proper appraisal of these huge and sprawling global innovation fronts, driven by commercial ambition and founded on a determined prosecution of a particular and contestable vision of global social benefit.

In this chapter I use the comparison of indigenous and scientific cultures to hold up a mirror to scientific risk assessment as it has been institutionalised for GMOs in the EU, US and other developed countries, as well as in international bodies such as the Codex Alimentarius Commission and the World Trade Organization. This allows us to examine how it might need to be developed – not only technically but also institutionally – from what are these free-market and free-trade priority settings, in order to navigate responsibly in fulfilment of the global, sustainability-founded agro-biodiversity requirements of the Biosafety Protocol and the CBD.

Some shifts in late 20th century science

Environmental risk assessment was introduced only in the 1970s in the US and Europe, and in quite limited ways. Later it began to be institutionalised for attempting to predict likely harm from new chemicals, radioactive or other non-ionising radiation exposures, and similar risky processes and materials. Indeed, the beginning of regulation of proposed deliberate environmental releases of GM plants for agricultural testing in experimental plots, with the 1990/220 Directive in the EU, was the first explicit reference to precautionary thinking (in the preamble, not in the legal articles), in that a step-wise risk assessment was established even though no environmental harm from such GM plants had yet been found.

Complexity and Reduction

This implied claim to a precautionary regulation just because no manifest harm had been seen before conducting risk assessment still begged serious questions about how well-known and under control or not were the biological processes involved as the basis of risk assessment knowledge as well as of the production of the GM constructs. Although the strong claim is that complexity has been embraced by modern science, including risk assessment, many examples show this to be untrue (Mattick & Gagen 2001; Grewal & Moazed 2003; Wynne 2005; Wilson et al. 2006). Here, without any claim to scientific literacy, ordinary people seem intuitively aware of issues which scientific regulatory authorities have neglected; of the limits of scientific control, the relentless generation of unpredicted consequences, and the breakneck speed of attempted translation from fragile cutting-edge genetic research-knowledge of possible technologies, to well-tested market products and profits (Marris et al. 2001). Here it is important to note that scientific claims for the extreme precision of GM technology were false, in that however precise might be the excision of genetic material from the original organism's genome, the insertion of such desired alien fragments into the new host plant's genome is extremely crude and unstable, requiring extensive monitoring, selection and discard. Moreover, the idea that such transgenes offer precise, reliable controlled traits was established before the human genome mapping indicated the falsity of the 'central dogma' of genetics, that one gene reliably creates one protein, which reliably codes for one specific trait. That the many fewer genes (*c.*20,000 found, against the 150,000 or so expected) do not operate so deterministically, because surprisingly there are too few genes for this mechanism to be valid, has major implications for the unstable behaviour, under varying conditions, of the crop and food genetic constructs so created, and thus for environmental and maybe also human or animal health risks. The EC (2005) recognised this problem implicitly in its evidence submitted to the WTO in the dispute with the US, when it affirmed that:

> It is not scientifically reasonable to simply translate and extrapolate the limited risk assessment results on the toxicity of Bt maize to human and non-target organisms from USA, Australia or some other non-European countries because the
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> regional growing environments;
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> scales of farm fields;
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> crop management practices;
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> local/regional target and non-target species considered most important
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> in the agri-ecosystem;

> interactions between cultivated crops; and surrounding biodiversity;
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> could each differ from published non-European studies, and could differ substantially between regions and countries within the EC.

Yet paradoxically, in EU regulatory practice itself, these EU-generated observations are ignored, and standard EU-wide risk assessment is accepted as sound science. The unstated reason is the greater priority given de facto to the EU single market, which to be viable requires a single regulatory risk assessment system. The WTO's Agreement on Sanitary and Phytosanitary Measures (SPS Agreement) risk assessment rules operate in a similar fashion, thus undermining the need in rigorous science for all situation-specific local variations in salient conditions to be recognised (Winickoff et al. 2005).

As indicated, a first basic shift in science since the 1950s is its central and pervasive role as policy authority, not only in answering the questions posed by policy, but also now in defining what those questions should be. The more this role has intensified, the less 'science' has been identifiable with scientific *research*, the more industrialised and instrumental it has become, and as a result, the more intellectually reductionist. Hence, the inability of institutionalised risk assessment to address complexity has been exacerbated, just as complexity and the condition of lack of control (that is, ignorance) which always stalks science have become more important.

Representation as Performance: Technoscience, Innovation and Social Benefits
As science has become more intensely and systematically commercialised, imaginations of its social purpose have increasingly closed around commercial exploitation in existing systems of value. These are rich Western consumer markets, and demand in such systems does not at all correspond with priority human needs in the global systems of investment, techno-scientific research, innovation, production, and exchange which prevail. In a special issue of *Nature Biotechnology* published in October 2004, on systems biology, an article asking 'Can Complexity Be Commercialised?' explained how:

> With a top-down approach which characterises much of today's systems biology, researchers start at the phenotypic or event level of a disease and *drill down* through functional pathways to only what is important in a specific disorder, because that disease phenotype is what they want to change … to speed up drug discovery and development and to make it much more efficient … and to use information from disparate data-sets to create computational models that can describe and predict phenotype at the cell, tissue or organismal level [so as to assist commercial drug-development for] … systems biologists to come up with tangible results to show investors. (Mack 2004)

This is the same systems biology which the UK's basic biology science research council (the BBSRC), describes as 'the science base' – pure science which is supposed to be free of social imaginations as to what might be the applications of science. The protein scientist Hans-Jorg Rheinberger (1997; 1999) has described in the same light how the molecular biological approach is no longer to try to observe and represent what is happening in sub-cellular processes. It is to use these processes within the cell as a technological experimental micro-laboratory, to see what can be made to happen.[6] The same has been true of plant science research, where the social imaginations of GM technological global agriculture have shaped innovation trajectories well before questions of risk arose for assessment.

[6] Of course, these are not mutually exclusive projects. The technological project still generates valid knowledge as a by-product, but the selectivity of this knowledge is systematic, limited by the technological ends which are imagined and invested in it. Thus, it excludes potential knowledge too, and these blindnesses may be just the origins of future unpredicted consequences externalised and deleted from responsibility by the risk culture that pretends to encompass all possible uncertainties with risk scientific knowledge.

The logic of recognising this unnoticed embodiment of unaccountable innovation commitments into science *before* risks and consequences become a question, and the endemic inadequacy of risk assessment to identify all possible consequences is not to shut down all innovation. It is to ask the extra questions that *rigorous* risk assessment requires – is the innovation worth it? What imagined social benefits is it intended to bring? To whom? Are these the most important purposes, and the most effective means?

Here it is worth thinking of the Access and Benefits-Sharing (ABS) issues being negotiated under the CBD. The arrangement is that indigenous original knowledge-holders have their knowledge recognised by giving them a right to a share of the benefits (e.g. profits from a pharmaceutical product sold in rich Western markets), if and whenever these might materialise, perhaps in twenty years. These financial benefits, it is envisaged, will prevent those peoples from destroying their local biodiversity ‘goose’ which laid such ‘golden eggs’. However, as Mack’s account makes clear in passing, there is no debate or reflection as to what might constitute an imaginable benefit worth respecting. It is pharmaceuticals, or equivalent high-value goods which will be available to rich Western consumers. Any possible alternatives are simply not entertained as a question, let alone a serious possibility worth assessing. Similarly, this is how risk assessment has arisen in Western regulation, in that if any technological innovation, such as a drug, is promoted by anyone for licensing and thus regulatory risk assessment, it and the profits it may bring to someone are automatically defined as a public good, and thus no debate about benefits to society is even imagined. Under the pressure of indigenous reactions to bioprospecting, and the CBD ABS arrangements, these questions, about what kinds of benefit should be defined and accepted, are now being posed for consideration, by the indigenous networks represented (Oldham 2006). Likewise, interestingly, equivalent benefits questions are now being entertained by European regulatory authorities responsible for risk assessment, as a possible fourth-hurdle regulatory set of questions in addition to risk questions themselves. As explained in the EEA (2002) Precautionary Principle book (see also Wynne & Felt 2007), a rigorously sound scientific approach to scientific uncertainties in risk assessment would address the predicament of unknown as well as known possible risks, and one logical response to this (among several) is to address the question of whether the promised benefits are (a) realistic, (b) socially accessible to all, in principle, and (c) important, for whose social needs? Thus, a fourth-hurdle regulatory question with regard to social benefit and the need to weigh these in with the risk questions, is a logical consequence of rigorous scientific risk assessment.

Given the certainty of such unknowns and thus ignorance in developing countries’ risk assessments for GMOs under the Biosafety Protocol, and given the different conditions salient to social benefits appraisal, such a social benefits question is rational for developing countries too.

Risk Assessment and Falsehoods of Control: Risk as a Relational Issue
Returning to indigenous knowledge, anthropologists (e.g. Richards 1993; van der Ploeg 1994; Graeber 2001; Ingold 2003) have shown how social-relational concerns and commitments are built silently into reasoning and valuation processes in such cultures. They are not so exposed to deliberate instrumental forces as they are in scientific cultures, and knowledge is embedded more into such social practices and relations. With Western scientific risk assessment, these relational dimensions are simply buried by the scientific framing. Once one recognises that risk as *known* possible consequences *always* carries further questions about unpredicted and *unknown* consequences, the relational issues stand out starkly. If there will be unpredicted as well as predicted consequences, it is necessary to ask who will be in charge of the social responses to such surprises – and can we trust them to react responsibly, in the public interest? Publics understand that they depend on such institutions, unavoidably; thus, this relational trust question

follows unerringly from appreciation of the predicament of ignorance which unavoidably attends scientific knowledge – and which becomes more significant the more ambitious science's interventions, and claims.

This relational question is intrinsic to risk; it is not an optional extra. Yet it is buried by the way science has been institutionalised in risk assessment and regulation and policy, and how it has thus been shaped intellectually. It has been recognised only belatedly that past interventions since colonial times into indigenous peoples' ways of life and environments, have been founded on the false premise that their culture was irrational and intellectually vacuous – similar in key respects to the same kinds of false patronisation of developed-world publics (Irwin & Wynne 1996; Wynne 2006). That both indigenous peoples and Western publics in their different ways seem to recognise complexities beyond the imagination of instrumental science (which is characterized by its commitment to the control, reduction and externalisation of unknowns) is a deep cultural and ethical difference which science has yet to acknowledge. The lack of expectation of control practised by both indigenous cultures and typical Western publics allows for these complexities to be sensed, recognised and adapted to through ad hoc improvisations, even in the absence of highly-elaborated instrumental knowledge.

In indigenous cultures anthropologists have described the various skills for handling these kinds of unknowns and insecurities, in belief systems which are more rooted in living relationships and dwelling practices than typical mainstream Western culture, and where public knowledge is required to be impersonal and objective. One important perspective on this is given by Ingold (2003), who distinguishes between engagement and living in the world, and detachment and alienation from it, as in Western notions of 'the global environment':

> To the extent that it has been used to legitimate the disempowerment of local people in the management of their environments, this ['global environment' discourse] – the privileging of the global ontology of detachment over the local ontology of engagement idea has had serious practical consequences for those amongst whom anthropologists have conducted their studies. To adopt a distinction from Niklas Luhmann, it might be argued that the dominance of the global perspective marks the triumph of technology over cosmology. Traditional cosmology places the person at the centre of an ordered universe of meaningful relations .. and enjoins an understanding of these relations as a foundation for proper conduct towards the environment. Modern technology, by contrast, places human society and its interests outside what is residually construed as 'the physical world', and furnishes the means for the former's control over the latter. Cosmology provides the guiding principles for human action *within* the world, technology provides the principles for human action *upon* it. … It is a movement from revelation to control, and from partial knowledge to the calculated risk. (Ingold 2003: 216)

We should also notice how this shift to 'the calculated risk' also involves an implicit projection of an exaggerated degree of control, and a tacit externalising of any lack of control onto others, thus a denial of responsibility for unknown consequences, even ones which may have been engendered by the same modern practices. The extant unresolved big question is whether we can find ways out of a treatment of these distinctions as monolithically either-or. Can we, as Verran (2002) asks, work them together, so that our instrumental techno-scientific powers might be organically regulated, and inspired, by cultures of negotiated human-relational, societal ends and priorities, rather than become their own instrumental, self-justifying ends?

An example of what Ingold's distinction means in practice is given in the work of fellow-anthropologist Paul Richards (1993) on African indigenous agriculture. He describes a complex system of intercropping of different crops and cycles, which is described by Western scientists as a combinatorial logic of a quite sophisticated, pre-planned design. From close observation over long periods of living with the farmers, he notes instead that there is a continually adaptive practical culture, in which the eventual outcome is not previously imagined and planned. Instead, it is achieved as a contingent outcome, through a succession of sequential improvised adjustments to unpredictable changes. As Richards says, a scientific frame of thought imposes a 'fallacy of misplaced abstraction', which replaces what are situated practices with no prior design, only adaptive skills and resources, with a false notion of 'indigenous knowledge-system' akin to the conventional image of science.

In other words, indigenous knowledge-culture is bringing tacit skills learnt from practice and historical experience to bear on a particular matter in a particular situation. Science also relies on tacit situated practice-knowledge (Polanyi 1958; Collins 1983), but its 'situations' are much more highly-orchestrated, limited and controlled. This exposes profound cultural differences, not just 'knowledge-gaps', between indigenous and scientific cultures. Hobart (1993) and Vitebsky (1993) describe these knowledge-practices in similar terms to Ingold and Richards, as situated, continually adaptive and learning in an experimental practical form, but within an ethical and epistemic idiom which does not expect nor seek control (and thus deny and externalise uncontrolled effects) in the way that scientific culture does.

Scientific Reductions: Indigenous Complexities
Van der Ploeg (1993) has described similar deep cultural dislocations in the interventions of Western scientific potato breeding into indigenous Andean potato-farming cultures. The approach of Western science is first to develop in a research laboratory one (standard) 'optimal' seed/plant (genotype), then to manage conditions – soil, inputs, environment, farmers' practices, etc. – to optimise production according to the laboratory object's standard conditions. According to van der Ploeg (1993; 217), 'One of the consequences of this … is that the new genotype will only prove to be an effective and rational innovation insofar as these required conditions can be effectively reproduced in the fields'. This also makes the crops dependent on a single optimised harmonisation of genotype and conditions, thus making them more vulnerable to change and variation, i.e. less resilient.

The potato farmers interactively cultivate different plots, using and exchanging multiple cultivars whose history and performance under different conditions they know, and share in their communities. Each farmer deals with a huge variety of ecological conditions: soil, temperature, water, drainage, wind, past cultivars, height, shelter, sun, rain, pests, etc. One factor may alter another. They thus begin from variable phenotypical qualities and environmental conditions, and select multiple – up to one hundred – seeds/plants (and their genotypes) to suit these. In this more complex and experimental optimisation process they use 'folk taxonomies' economically to describe their cultivars. For example, one potato variety (*ccompi*) is sometimes called another (*calhuay*) not because of error, but because *in certain conditions*, it shows properties of the other. Likewise, environmental and other inputs variables interact in complex dynamic ways, and these are reflected in economical forms of tacitly combined reference. Thus, 'high-low' altitude interacts with 'hot-cold' temperatures, depending on wind, shelter, soil richness, etc., so that a plot higher in scientific altitude terms, may be 'lower' in indigenous farmer terms, because the soil was previously more tilled, or because of lower wind exposure. Unaware of the indigenous meanings, scientists deem this ignorant. Echoing Vitebsky's aforementioned observations, 'when one separates these concepts from the people who use them, or from their context, they do indeed become 'inaccurate'' (van der Ploeg 1993: 212)

These indigenous descriptive terms do not refer to a supposed universal and abstracted reality, as is the assumption of scientific culture, but they are locally specific, flexible and practice-related in meaning. Moreover, these more informal theoretical terms are open to change, according to experience and need. The farmers are collectively practising a form of experimental knowledge which is being continually developed according to empirical experience and social-cultural needs, including normative cultural commitments to long-term sustainability and ‘pay-off’, not just short-term. Thus, van der Ploeg (1993) notes, the forms of farmers’ technical reference and practice are consistent with, and reflect and help to sustain existing community relations and social practices. They have not been isolated into individualistic or short-term notions of optimisation, productivity, efficiency, and ‘validity’, whereas the scientific culture assumes implicitly that if its own system’s yields begin to drop after a few years – as, indeed, was found to happen in van der Ploeg’s situation – new laboratory genotypes and/or artificial inputs such as chemicals will remedy this.

Once the Western scientific system entrenches itself therefore, the dependency of the indigenous culture on the techno-scientific inputs and corresponding modes of life relentlessly increases, and the independent, experimental collective knowledge-capacities of its members is relentlessly diminished. This social-technical knowledge-capacity may be a very substantial positive value whose systematic destruction has yet to be adequately recognised in existing forms of regulatory appraisal and risk assessment, and their narrow and parochial definitions of (physical) ‘harm’.

Conclusions

In this chapter I have used what are now common anthropological insights into indigenous cultures (including into ‘indigenous’ citizen cultures in developed-world societies) to provide a clear profile against which to see some of the unseen cultural dimensions of scientific risk assessment as the defining modern approach to decision making about such issues such as the commercial use and international trading of GM crops and foods between developed and developing social and agricultural settings. The point is emphatically not to ask which of these is better. It is more to help develop a more mature, indeed more scientifically rigorous and self-reflective, practical culture in the established methods and processes of risk assessment which define these policy decision-making commitments. This would also bring (a) a much-needed modesty to such regulatory claims about the scientific knowledge which is so used to claim public authority for the innovation trajectories as well as the risk assessment judgements themselves, and (b) a recognition that rigorous approaches to risk assessment take us beyond existing reductionist scientific framings of ‘risk’, and require institutional developments such as social benefits appraisals to prevailing regulatory ‘risk assessment’ processes.

Such a comparative outline, albeit far too brief, shows how the defining institutional scientific methods and assumptions of global and national risk assessment are already framed in various ways which prejudice outcomes in particular directions. For example, the universally institutionalised presumption that only risks need to be assessed and not claimed or imagined benefits, because historically – until the European controversy over GM crops and foods emphasised public refusal to believe promotional claims about benefits – it was just taken for granted that if anyone wanted to promote a particular innovation, by definition it was a social benefit. For GMOs this has now been challenged openly, but its more general logic has not been at all adequately assimilated into an institutional and policy change which, as the 1995 Norwegian Gene Technology Act has been almost unique in doing, would ask the fourth-hurdle, social benefit questions and weigh these in with the risk questions. For the very different conditions, needs, and priorities of developing countries this may be an even more important extra regulatory question than it is for developed societies; and it would almost certainly lead to different outcomes, in whichever particular direction. Of course, the collective answers to such benefit questions would not be precise ‘revelations’ from nature by technically validated analysis, as risk assessment is supposed to be. Yet as many authors have shown, this is not fully true for risk assessment anyway (Wynne 2001; Stirling 2003; Jasanoff 2005; Chapter 3 in Wynne & Felt 2007).

When, as these analysts have done, we examine risk assessment as knowledge-culture more closely, it is clear that important social-cultural premises have always framed the scientific risk knowledge process – about what count as salient, defining questions, including what counts as harm, to what socially valued entities. Moreover, the precision that is always taken to define sound science itself tacitly embodies and imposes normative values commitments which are thus protected from accountable debate. This epistemic criterion inevitably reduces recognised risk possibilities to immediate, measurable ones, and from immediately recognisable elements of the technological trajectory which is being socially appraised for decision. The larger, longer term more extensive commitments realistically rendered more likely by the first (more precisely definable) step, are framed out of risk assessment defined by the precision criterion, even though realism and wholism as other legitimate criteria for valid knowledge ought to include such larger questions, even if they are less precise.

The point here is that a proper debate about social benefits and purposes of innovations, as in agricultural change, would automatically include debate about the social purposes and values of prevailing knowledge, including the knowledge invested in the innovations in question, its degree of social centralisation, private ownership and control, and the extent to which it encourages or prohibits distributed knowledge skills of groups such as farmers in van der Ploeg's example of the previous section. This kind of institutional and intellectual framing would then also render scientific risk knowledge more socially responsive and grounded in realistic reflection of such societal debates, values and needs. This would not at all reject science, just frame it more openly, constructively and effectively, as proposed, for example, in developing country GMO cases in Chapter 10, as well as by earlier science policy reports which have been ignored (USNRC 1996; UK RCEP 1998).

Resonating with the aforementioned conclusions are also the logical outcomes of taking the uncertainties within and underlying scientific risk knowledge more rigorously than institutional risk assessment does. The differentiation between risk, uncertainty, ignorance, indeterminacy, and ambiguity exposes the point that while risk assessment may include uncertainty in the form of known possible consequences whose probability we cannot estimate, it never addresses ignorance, because this is strictly impossible. However, this does not make it negligible. Nor does it justify denial, as presently happens to the public discredit of risk assessment and scientific institutions. Addressing benefits questions, as explained, is one such logical response; but so too is building in debate and assessment of alternative trajectories, and not only in technical risk terms but in social terms too, including the distributed knowledge-capacity issues outlined earlier in this chapter. Diversity of portfolios may also be a rational approach, especially when exaggerated speed of commercialisation and immature scientific knowledge underlie the technology and its regulatory risk appraisal.

The key differences between scientific and indigenous may be more in their different, perhaps incompatible ethical, cultural and social substance, than in any more systematic logical aspects. To use a common philosophical parlance, it may be more about forms of life, than about abstract logical or reason-based, intellectual criteria.

I have tried to summarise the implications of insights into scientific and indigenous cultures for biosafety assessment of GMOs, bearing in mind that 'biosafety' questions cannot as a matter of reasoned principle be divorced from wider questions about social benefits, and purposes, thus about what kinds of institutional structures, of ownership, control, accountability, and direction are shaping innovation scientific research and not only biosafety research in a domain of this kind. It cannot make sense to attempt to do rigorous assessment of the potential impacts of a science-driven technology such as GMOs without also asking about the quality and (im)maturity of the scientific knowledge that has given rise to them in the first place, what aims and expectations were driving it, and what technical and social alternatives are, or if we invested in the research, could be, available.

Examining the relations between scientific and indigenous knowledge-cultures thus provides some helpful perspectives out of which to construct more robust, more just and sustainable forms of innovation and more rigorous, more publicly legitimate forms of risk assessment and appraisal, than have so far been established in developed or developing countries, for innovating and shaping agricultural development globally.

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