First published in June 2002
by
The European Science and Environment Forum

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Cover photo courtesy of National Oceanographic and Atmospheric Administration and the US Department of Commerce. Ref www.photolib/noaa.gov/historic

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Perilous precaution: the folly of disregarding science

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Introduction

The precautionary principle sets out how to make environmental decisions in ignorance. The international standard definition among policymakers is that set out in the Rio Declaration in 1992.

> Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.
>
> (Article 15)

As Indur Goklany points out, this should result in policies which proceed carefully, with circumspection, making continuous analysis and assessment of the dynamic environment in which an action takes place, and of the effects of that action.

The alternative is not to proceed: to develop nothing; to invent nothing; to improve nothing. It is becoming ever clearer that those espousing this 'principle' want to control development. Perversely, the precautionary principle has been used as the basis for aggressive, world-scale policy in the hope of stopping change. The consequences of such policies are given little consideration – even where cursory analysis shows them to be tragic. The case made by Roger Bate against the banning of DDT for malaria control in Africa is utterly conclusive and yet there is strong resistance to it among western intelligentsia and bureaucrats.

In the name of precaution, sloppy reasoning is used to skirt around fundamental scientific uncertainties; opinion is placed above knowledge in the decision-making calculus; baseless assumptions are made in order to reach a consensus. As Robert Nilsson has seen to his dismay, sometimes science is simply disregarded. The implications of taking 'precautionary' action are rarely considered – even the Kyoto Protocol was assumed until recently to be costless.

The inevitable result is bad policy. As science advances and real knowledge replaces assumptions that underpin a policy, that policy will probably become obsolete – either because the assumptions are simply wrong, or because a better understanding of a problem will enable a better remedy.

This booklet brings together three diverse narratives illustrating the sorry consequences of action taken in the name of the precautionary principle.

Biographies

Roger Bate

Roger Bate is a Director of the International Policy Network, a fellow of the Institute of Economic Affairs, London, an adjunct fellow at the Competitive Enterprise Institute, Washington DC, and a Visiting Professor at the University of Buckingham. He founded the Environment Unit at the Institute of Economic Affairs in 1993 and co-founded the European Science and Environment Forum in 1994. He is a board member of the South African non-governmental organization, Africa Fighting Malaria.

He has a PhD from Cambridge University and has advised the South African Government on his dissertation topic of water allocation in South Africa. Dr Bate is the editor of *What Risk?* (Butterworth-Heinemann, 1997), a collection of papers that critically assess the way risk is regulated in society. He has also written several scholarly papers and numerous shorter scientific articles, for newspapers and magazines, including the Wall Street Journal, the Financial Times, Accountancy, San Francisco Chronicle and the Los Angeles Times. His articles were published as a collection in his book *Life's Adventure: Virtual Risk in a Real World* (Butterworth Heinemann, 2000).

Indur M. Goklany

Dr Goklany, the author of *Clearing the Air: The Real Story of the War on Air Pollution*, has more than 25 years' experience of addressing environmental and natural resource science and policy issues with state and federal governments an the private sector in the USA. He has published extensively in various peer-reviewed journals on air pollution, climate change, biodiversity and the role of technology in creating, as well as solving, environmental problems. Being Indian-born and bred, he is keenly aware that, despite the best of intentions, First World sensibilities can often aggravate Third World problems – DDT and GM crops being cases in point.

Robert Nilsson

With a background in biochemistry and radiation biology, Robert Nilsson joined the Swedish EPA in 1974, and became head of the toxicological unit of the Products Control Division where, he was instrumental in pushing through regulations on reductions of lead in gasoline, as well as the first general restrictions in the world on the use of cadmium.

In 1986, responsibility for chemicals control was largely taken over from the Swedish EPA by the newly created National Chemicals Inspectorate (KEMI), an agency that currently employs him as senior toxicologist.

He has worked for the OECD Chemicals programme as well as for WHO and has advised the Ministries of Environment of the governments of Iran and India. During

the last 10 years he has devoted himself mainly to research-oriented activities in his capacity as adjunct professor of molecular toxicology and risk assessment at Stockholm University.

His position as member of the executive board for the International Society of Regulatory Toxicology and Pharmacology in the US, between 1994–1999, as well as his role as technical advisor in products liability litigation, sometimes directed against industry interests, underline his continued interest in the 'politics of chemical risk'.

Dr Nilsson recently accepted an appointment as professor in toxicology and advisor to the key institution supplying the new Polish government with input for creating and supervising a modern regulatory system for chemicals control.

ESEF thanks the International Policy Network for providing sponsorship of this project.

Misguided precaution: chemicals control and the precautionary principle in Sweden

Robert Nilsson

The role of politics in chemicals control in Sweden

Over the past few decades, I have been deeply involved in the development of chemicals legislation in Sweden, and have seen how the concepts behind the legislation have been exported throughout the western world. It is the international impact of these chemical controls that compels me to make some general observations about how these concepts were developed.

In Sweden, the main impetus for improved environmental protection, including chemicals control, came originally from the scientific community. For instance, the bioaccumulating and toxic properties of organic mercury compounds used in agriculture were appreciated some time before the Minimata poisonings in Japan became known. In the years 1964–1966 the Swedish chemist, Sören Jensen, was the first to describe the bioaccumulating properties of PCBs. Initially, the fight for a better environment was an uphill struggle, where industry and government alike showed great reluctance to adopt a more progressive and responsible attitude. Although media coverage certainly played an important role, arguments presented during this early phase were mostly technical, and many respected scientists were closely allied with the founders of the Swedish environmental movement.

In 1969, the Swedish producer of Thalidomide accepted responsibility for compensating the damage caused. This was a turning point and for more than a decade a balanced and gradual progress was made in various fields of products control, largely based on scientific principles. A notable exception was the dioxin hysteria, which provoked direct intervention at ministerial level in the 1970s to restrict, and later ban, many of the chlorinated phenoxy herbicides.

Regrettably, in spite of significant scientific progress in toxicology and risk assessment, the role of high quality science has gradually become less important in shaping Swedish national policy priorities for chemicals control. Worse still, good science plays an ever-smaller role in influencing the environmental movement, which, to a large extent, has been hijacked by extremists. Instead of focusing on the conservation of wildlife, where much good has been achieved, many respected naturalists started to busy themselves with complex toxicological problems, an area in which they had little or no training. With respect to chemical risks, environmental pressure groups nowadays mostly preach a primitive ‘eco-fundamentalism’ based on ignorance of the scientific issues involved, while showing little understanding of the economic laws of a society that provides them with all the basic conveniences and luxuries that they actively consume.

By controlling a block of MPs that can swing votes in favour either of the socialist block or the liberal/conservatives, the Swedish Green party, like the German Greens,

exert a substantial political influence. In addition, Swedes have been nurtured on a distrust of 'experts', so it is perhaps not surprising that Greenpeace often seems to have more influence on the Swedish Ministry of Environment than does the Royal Swedish National Academy of Sciences. Naturally, such tendencies have disproportionately affected government agency policies, because of the inclination of many politicians to play the environment card to secure support of marginal voters. This has, unfortunately, boosted the influence of environmental groups to an extent that bears little relation to the number of actual members.

In 1979, the Swedish Government commissioned a special group, including some of Sweden's most prominent scientists, led by the Nobel laureate in medicine, Sune Bergström, to assess the reasons for cancer among the Swedish population, as well as to suggest preventive measures. I participated in this work, and in 1984 an extensive report of the Swedish Cancer Committee (SCC) was presented to the Government. The report's conclusions were not what the politicians had expected and they were apparently disgusted: apparently, they had hoped it would give the socialists marginal votes in the forthcoming elections. What activist politician wants to hear that, in comparison with sunbathing, for example, industrial chemicals, pesticides and air pollution are not significant causes of cancer? They could, of course, accept that smoking was bad, but obviously did not want to convey the message that diet was considered an important factor in avoiding cancer, not to mention that bad genes also play a role. The SCC conclusions were practically identical with those presented by the famous epidemiologists, Doll and Peto, to the Office of Technology Assessment of the US Congress in 1981.

Politicians wanted to avoid such political mishaps in the future, so in 1996 when the Swedish Ministry of Environment was looking for specialists on chemical hazards to assist in drafting documentary support for new legislation, did they ask the Royal Swedish Academy of Sciences, or perhaps the famous Karolinska Institute which selects nominees for the Nobel Prize in Medicine? Sadly, not: the job was conducted mainly by bureaucrats and politicians associated with the Ministry, assisted by some junior consulting firm employees with little knowledge of toxicology. A few true scientific experts, diluted by a majority of laymen, were engaged to serve as hostages with little possibility of influencing the work. Whereas the report of the Swedish Cancer Committee was translated into English and published by a major international scientific publishing company, (Ministry of Social Affairs, 1992), the 1997 report from this 'Chemical Committee' called 'A Sustainable Policy for Chemicals', was a major disaster and received scathing criticism from, amongst others, the Swedish Royal Academy of Sciences and the Royal Academy of Engineering Sciences. To a Minister of Environment (now Minister of Foreign Affairs), Anna Lindh, who declared that she has more confidence in Greenpeace than in the Academy of Sciences, expert criticism was to no avail, and the

recommendations from this committee now form the ideological basis for one of the most extreme chemical laws in the world.

The Swedish regulatory process

The role of Swedish government agencies is to implement the laws enacted by parliament. Traditionally, these agencies have been relatively autonomous. However, in recent years ministers have increasingly interfered with the daily work of the agencies, acting mainly through politically appointed managers on several levels.

The central agency for chemicals control, the National Swedish Chemicals Inspectorate (KEMI) has become a powerful instrument for the promotion of the green ideology favoured by the present socialist government.

Tendencies as those described above are, no doubt, more or less common to most developed nations, but what distinguishes Sweden from most other countries is that environmental extremism has a strong influence on society. There are several reasons:

A high level of public concern for environmental protection, especially with regard to ‘environmental poisons’.

An omnipresent, centralised and highly politicised regulatory bureaucracy, combined with a lack of balance of power between regulators, industry, and private interests.

Lack of coherent national strategies for risk assessment and risk management, where the negative consequences are accentuated by the absence of risk–risk comparisons in the regulatory context.

A mistaken belief that efficiency in chemicals control is proportional to the number of bans and restrictions imposed.

A firm conviction of the unmatched excellence of the Swedish model, combined with a pioneering spirit when attempting to convert an ignorant and callous world. Sweden has a strong tradition of cherishing unspoiled nature. It is based on a romanticism of the past, and is held not only among Swedish intellectuals, but also prominent industrialists. In a positive sense, this has probably promoted the progress of traditional environmental protection as well as encouraging the introduction of stringent emission controls to benefit the quality of life. It is true that in comparison with most other industrialised nations, Sweden has relatively few serious environmental problems today. However, when I am confronted with media reports about the state of the environment in this country, it is often difficult to recognise the descriptions, since they seem to be more appropriate to México City, Calcutta, or to certain devastated areas in industrialised Eastern Europe.

It has also been claimed, that the level of risk acceptance in Sweden is particularly low. This over-sensitivity may be true for a nation that has not experienced war since

Napoleonic times, and where other national disasters have been scarce. In addition, the 'worry box' concept of the US American humorist Patrick F. McManus (1992) seems to be eminently fitting with respect to many of its citizens:

> It's as though a person has a little psychic box that he feels compelled to keep filled with worries… When one worry disappears from the box, he immediately replaces it with another worry, so the box is always full. He is never short of worries!

Even when the level of worry among the public (news media) may appear to be more or less constant, the issues of concern may change, and sometimes this happens from one day to the next.

In the past, belief in witches and witchcraft was widespread in our society, including the Church. However, some powerful enlightened rulers in the 17th and 18th centuries, including King Gustavus III (1771–1792), had both the determination and courage to combat ignorance and superstition. Today, Swedish politicians more or less openly admit that, rather than basing their policies on real risk, they are mostly guided by 'risk perception', a concept heavily tainted by a new kind of superstition. Instead of making an attempt to distinguish between what are significant and insignificant risks, our regulators tend to yield to media blackmail that will only accentuate the trend towards an increasing lack of rationality in risk management to the detriment of progress in modern society. Each time regulatory action is taken that is based solely, or mostly, on public 'concern', and where the actual risk is negligible, the mere fact that regulatory action is taken will strengthen the belief in its absolute justification. The layman critical of experts will exclaim: 'You see, it was dangerous – we were right after all!'

The EU perspective

Will Swedish membership of the EU strengthen the role of science in domestic regulatory affairs? With a past experience in independent expert groups convened by such bodies as the OECD Chemicals Division, the Joint FAO/WHO Meeting on Pesticide Residues, and the International Programme of Chemical Safety (IPCS) in Geneva, I had high expectations of similar groups working under the EU. The Commission has the powers to appoint expert groups to deal with general topics, such as guidelines for risk assessment, classification, and labelling, where the members as a rule act relatively independently and, above all, have adequate scientific qualifications. When such guidelines are issued as EU Council Directives, they become legally binding for all member states. As a consequence, one can already note a sobering influence of EU membership on Sweden's regulatory policies in general.

However, I have been somewhat disappointed when working on the Existing Chemicals Programme. This programme generates comprehensive documents for individual high volume chemicals and contains, for example, recommendations for classification and risk reduction that have far reaching consequences for the

European chemical industry. For this reason they deserve a better fate than the kind of political toxicology displayed by the participants from the various national government agency bureaucracies. The historic domination of the Union by left wing governments is here clearly discernible.

Securing grants at all costs – the responsibility of the scientist

It would be unfair to blame biased policies entirely on ill-educated laymen, or opportunistic bureaucrats and politicians. The scientific community itself shares part of the responsibility for this unfortunate development. In many cases, researchers with little knowledge of toxicology have acted far outside their own field of competence and provided fallacious interpretations of their results, while shamelessly exploiting the news media to promote their own interests. Even when discounting such excesses, in order to secure continued funding with respect to certain 'grant-dense' areas, like health risks from chemicals, professionals in medicine and epidemiology often tend to overextend interpretation of their own data. In a commentary in the famous US journal *Science* (Taubes, 1995), one scientist affiliated with the prestigious US National Institute of Environmental Health Sciences bluntly stated that:

> Investigators who find an effect get support, and investigators who don't find an effect don't get support. When times are tough it becomes extremely difficult for investigators to be objective.

It is sometimes realised that a rational policy for chemicals control would demand extensive inter-agency cooperation, but concerted action is hampered by the tendency for bureaucrats to expand their own empire. Each agency tries hard not only to defend it own turf, but to make an attempt to expand its area of competence as much as possible. The public may not realise that the main threat to human health from chemicals in food today is not the presence of minute levels of pesticide residues, or of other industrial chemicals, but rather, the overeating of unhealthy foods including, in particular, a high intake of saturated fat, insufficient intake of fruits and vegetables, and the presence of natural toxins in food. However, if generally known, this could imply a diversion of financial resources from the competent agency for chemicals control to the agency for food control. This situation provides a potential for some unholy alliances between scientists and regulators:

> If, for example, the dioxin question was defused, several laboratories that for decades have specialised in dioxin-related research, and successfully milked agency and other funds for support, could lose its cash cow. After all, it may not be so surprising that no attention was paid to the call from the Swedish Cancer Committee in 1984. This committee emphasised the role of life-style as the main factor in causing cancer, and stressed the urgent need for a uniform regulatory policy for risk management based on quantification of risk that involved effective inter-agency cooperation (Ministry of Social Affairs, 1992).

Society's implementation of a double standard is particularly obvious in the regulation of pesticides. If the natural substances found in potatoes, solanine and chaconine, were pesticide residues, potatoes would fail as a consumer product on two counts: their high content of these toxic alkaloids (20–100 mg/kg), and; solanine and chaconine have not been adequately tested for long-term effects (IPCS, 1993). Neither would the common mushroom be allowed onto the market. Mushrooms contain the potent genotoxic carcinogenic hydrazine derivatives (agaritine) that induce a high incidence of malignant tumours at multiple sites in the mouse, in particular, in the forestomach, bone, and lungs (Toth and Erickson, 1986). Recently, the 'endocrine disrupter' scare has provided another striking example where exposures to such compounds of industrial origin are dwarfed by the extensive use of oral contraceptives and other 'natural' chemicals, and is also virtually insignificant in comparison with the intake of natural phytoestrogens with food (Table 1). Although exposures to man-made and natural chemicals occur by identical routes of administration and contribute to the same toxicological effects, they are, regrettably, being judged by completely different standards.

Table 1 – Mass balance in terms of oestrogen/anti-oestrogen equivalents of human exposures to natural as well as synthetic compounds that mimic the effects of sexual hormones.

Oestrogens/Anti-oestrogens	**Oestrogens/Anti-oestrogen equivalents (µg/day)**
Oral contraceptive[a]	16,675
Post-menopausal therapy	3,350
Flavonoids in foods (1 g/day)	102
Genestein and genistin (15.6 mg) in 100 g tofu (soybean curd)[a]	16
Zearalenone in 0.5 L Zambian beer	20–50
Zearalenone, daily average[c] intake from Canadian food (3.5–7.0 µg)[c]	0.1-0.7
Di-n-butyl phthalate in UK food (250 µg/day[b])	0.02
TCDD and related compounds (80-120 pg/day)	0.00008–0.0001
Organochlorine insecticides	0.0000025

a) based on in vivo potency relative to ß-estradiol in the neonatal rat;
b) assuming all intake to be dibutyl phthalate;
c) based on in vivo potency relative to ß-estradiol in the neonatal rat. (From Nilsson, 2000)

Commenting on the Swedish nation, Charles de Gaulle is once supposed to have exclaimed 'What a wonderful people to rule!' From his perspective I totally agree. Sweden's regulators employ the latest technologies and they are generally very efficient in their operations – much more so than US regulators. The agencies' servants are also dutiful in the extreme and probably among the least corrupt (in the classical sense) in the whole world. When French politicians introduce legislation that is generally considered stupid by the pragmatic and cynical French, even the bureaucrats ignore it, or at least find 'the resources insufficient' to give its implementation priority. Not so in Sweden. The faithful Swedish bureaucrat will do his best to implement any decree or regulation to the letter, with complete disregard not only of common sense but sometimes also of the nation's constitution.

In most democracies, those who reasonably believe themselves to be adversely affected by Government regulations have a constitutional right to an impartial hearing of their objections before an independent court. Such rights constitute an important safeguard against arbitrary execution of power. No such rights exist in Sweden. In the case of *Sporrong and Lönnroth v. The Government of Sweden*, the European Court of Human Rights noted that:

> Generally speaking, the Swedish administration is not subject to supervision by the ordinary courts. Those courts hear appeals against the State only in contractual matters, on questions of extra-contractual liability and, under some statutes, in respect of administrative decisions. Judicial review of the administration's acts is, therefore, primarily a matter for administrative courts.

The administrative courts in Sweden are not independent of the government, and are, in many cases, the highest court of appeal. In practice, this means that procedures, which from a purely formal point of view have been mishandled, may be challenged and remedied, but assessments never cover the technical basis for regulatory action, nor of the reasons for such regulations. Sweden also seems to be unique among modern democracies in not having even an independent court of appeal to judge the constitutionality of proposed laws and regulations.

Not surprisingly, a strong tendency to disregard the protection of the property rights of its citizens has long been a typical trait of the Swedish regulatory tradition that, *inter alia*, has resulted in 18 indictments by the European Court of Human Rights against the Swedish Socialist Government. 16 of these refer to Article 6, para.1, and two to Article 1 of Protocol 1 of the European Convention of Human Rights. The Human Rights Court has made it a point that many of the Swedish Government's decisions have not been,

> open to review as to their lawfulness by either the ordinary courts or the administrative courts, or by any other body which could be considered to be a 'tribunal' for the purposes of Article 6 para 1.

Article 6 relates to the right to a fair trial:

> In the determination of his civil rights and obligations or of any criminal charge against him, everyone is entitled to a fair and public hearing within a reasonable time by an independent and impartial tribunal established by law.

Article 1 of Protocol No. 1 (P1-1), reads as follows:

> Every natural or legal person is entitled to the peaceful enjoyment of his possessions. No one shall be deprived of his possessions except in the public interest and subject to the conditions provided for by law and by the general principles of international law.

Together with Italy's disreputable legal system, Sweden shares the dubious honour of being foremost in receiving indictments under these articles of the European Convention of Human Rights. For a country that in most other aspects has a solid and usually well-deserved reputation as a staunch guardian of human rights, this should indeed be embarrassing. More so for our prime minister, Göran Persson, who boasts that he is aiming at making Sweden an 'ethical superpower'.

The recently introduced unified Environment Code Act and associated ordinances contain some important changes. For instance, many cases in the field of environment protection will now be referred to the newly created Environmental Courts, with a separate Environmental Supreme Court as the highest level of appeal. These courts will, for example, judge on felonies with respect to the statutes of the Act, and will review refusals to grant exemptions under several environmental statutes. However, objections dealing with pesticide registrations can only be appealed to the Government, neither can the justification of an ordinance, or of a regulation issued by a competent agency, be challenged in an independent court of justice.

In Sweden, the Central Office for Government Auditing (Riksrevisionsverket) does perform assessments of government agencies, but these audits are mainly of fiscal character, and the agency's operation is not guaranteed independence from the government. Thus, there exists no professional and independent body that is empowered to judge agency policy and performance. Professionally substandard agency performance can, therefore, easily pass unnoticed.

This lack of professional external scrutiny, combined with the small size of the chemicals sector, and strong anti-industry sentiment in important parts of the public sector, has encouraged over-zealous regulation of the chemicals industry in Sweden. This is almost perfectly demonstrated in the following example.

Some years ago, an application for registration was made for a pesticide containing a natural plant growth hormone, used in small quantities to stimulate root formation in cuttings of woody and ornamental plants. It is used for this purpose all over the world. However, registration was not granted in Sweden. This is simple amino acid derivative with an extremely low exposure potential, involving a very small number of applicators. The primary reason for rejecting the application was not potential

health or environmental hazards, but that head of the Pesticide Division of the competent authority thought the product 'unnecessary'. From the point of view of national economy this was certainly true. However, for a handful of farmers who had invested much of their own money in greenhouse cultivation of ornamental plants, the availability of these growth promoters was important. Since no health or environmental risks were at stake, the sole consequence of turning down the Swedish growers' application for registration was to give the growers in other countries, especially the Netherlands, a significant competitive advantage.

The implementation of a common registration policy for the EU, which Sweden has been forced to accept, is actually most welcome from many points of view. KEMI clearly wants to avoid direct confrontation with EU, but persists in limiting the availability of pesticides by other means. One trick has been to classify nearly all pesticides that are available to the general public in other European countries as class II products, meaning that they can only be used professionally. Annex VI of the EU registration policy deals with uniform principles for evaluation and authorisation of plant protection products for entry onto the market (Council Directive 91/414/EEC). Although it requires exposure assessment to be conducted (Section 2.4.) to provide a basis for a proper risk assessment, there are at the present no indications that the Swedish authorities intend to comply with these EU regulations when it comes to pesticide products intended for the consumer. Some pesticides that were banned in Sweden were subsequently subjected to joint EU evaluation and found to be acceptable. The head of the pesticides division of KEMI has publicly declared her intention to combat the reintroduction of such pesticides. Further, in practice, the Swedish general public is barred from using just about all effective pesticides, although a large number of practically safe products do exist for various areas of application. Faithful to its socialist traditions, the investments of billions of Crowns by private Swedish homeowners in lawns, flowerbeds and rose-gardens lack protective value in the eyes of the Swedish State.

The withdrawal of several copper-containing anti-fouling paints for pleasure boats and marine vessels in the Baltic area based on alleged environmental hazards has led to a number of appeals to the Government. Our politicians will almost certainly uphold these rulings – along with the highly unpopular withdrawal of effective mosquito repellents. These appeals will then be carried to the Commission and then further to the European Court of Justice.

The precautionary principle

Instead of developing a rational strategy for risk management based on good science, defining what is and what is not a significant risk, widespread 'chemophobia' is now tackled by using the so-called 'precautionary principle'. At first glance, this concept seems appealing. It makes sense to 'look before you leap'; after all it is 'better to be safe than sorry'. But it is important to distinguish justifiable precautionary action –

based on sound science and an appropriate assessment of the costs and benefits of taking action – with unjustified precautionary action. The precautionary principle fails to distinguish between the two, by elevating to the status of universal 'principle' a notion that is only narrowly applicable.

An example of justifiable precautionary action is the restrictions that were placed on the use of the sedative, thalidomide, by the US and East German regulators. Across the world, thalidomide (Contergan, Kevadon, Distaval, Neurosedyn, etc.) caused more than 10,000 severely malformed children to be born to mothers who had used the drug during pregnancy. However, both the US FDA and the Drug Registration Authorities of what was then East Germany prevented the introduction of thalidomide. Both based their decisions on similar considerations. (Some have argued that the USA avoided the thalidomide disaster simply because FDA was too slow in processing the application from the manufacturer, Richardson-Merrell. This is not true.) Inadequate toxicological supporting documentation initially aroused doubts and suspicions. These were considerably strengthened by an alert, published December 31, 1960 (14 weeks after the application for regulatory approval was made to the FDA), that the drug induced polyneuritis, a side effect for which the documentation from the producers '...fails to make a frank disclosure…' (letter from FDA of May 5, 1961). Both the US and the East German agencies turned down the application for use of thalidomide during pregnancy. The President's Award for Distinguished Federal Civilian Service, made to Dr Frances Kelsey, the FDA official who played a decisive role in blocking approval of thalidomide, was well deserved.

Another example of justifiable precaution is the restrictions that were imposed in Sweden on emissions of certain cadmium compounds into the environment. These restrictions reversed a progressive build-up of the metal in topsoil, corn and human tissues, where kidney damage constitutes the end-point.

By contrast with these precautionary measures based on sound scientific evidence of genuine harm (and where the benefits arguably outweigh the cost), the broader precautionary principle seems to have as many interpretations as the number of administrators that are now using it Sweden. I recently asked one of our representatives working with the EU programme on classification and labelling of chemical substances why Sweden always has to take the most extreme position towards the harshest possible classification. The answer was the precautionary principle.

This made me think about what the precautionary principle actually means in the regulatory context. I have not been able to find much of legal reference, and indeed very little that I believe would be of any help to a judge in a modern Court of Justice. The Economic and Social Committee (2000) noted that,

> …there are as yet few legal bases for a precautionary principle and that case law is still in its infancy. Further, explicit and implicit allusion to this principle does not provide a solid base,

> and the Economic and Social Committee would ask the Commission to submit a concrete and viable case soon.

The Committee also noted that the precautionary principle seeks to extend what is known under public law as the 'policing powers' of the authorities, and that the implementation of this concept will have major implications at the international level in as much as:

> It enables countries to temporarily suspend their free trade commitments. The precautionary principle gives countries a sovereign right – and makes them the sole arbiter – on matters affecting the safety of their nationals. There is thus a stark contradiction with the EC Treaty.

It is no wonder that the Swedish Socialist Government loves the precautionary principle. Conceptually, it was already included in previous legislation and has rushed ahead of the European Community and introduced its own interpretation of this far-reaching principle in the new Swedish unified Environmental Code Act of 1998 (SFS 1998: 811) that came into force in January 1999:

> 3§ Anyone who carries out, or intends to carry out an activity or action of whatever nature, shall undertake protective measures, follow restrictions and undertake such precautions in general to prevent or counteract that the activity or action in question results in damage or inconvenience with respect to human health or environment. With the same aim, any professional activity shall use the best available technique. These precautionary measures must be undertaken as soon as there is reason to believe that an activity or measure can cause harm or inconvenience with respect to human health or to the environment.

The legal text actually uses the term 'inconvenience' ('olägenhet'), because the unified code covers everything from protecting the ozone layer to the manufacture and marketing of chemicals, the recycling of beer cans, or the building of a golf course. For good reasons, the proposal for the new Swedish legislation was harshly criticised by many legal experts, including the Government's own legal council, and to avoid a complete paralysis of the Swedish society, the new Code does incorporate a clause calling for some kind of proportionality between action and the desired level of protection. Thus the use of the precautionary principle should be reserved for situations

> where it does not seem unreasonable to implement the same. When conducting this assessment, the benefits of the protective measures and other precautionary measures should be related to the costs for implementing the same.

However, the main defect of the Swedish code is that there is no guidance as to when 'there are reasons to believe' that damage or inconvenience to the environment will occur, or when 'it does not seem unreasonable to implement' the precautionary principle. In other words, what degree of certainty (or uncertainty) is required to trigger actions based on this vague principle.

A second serious shortcoming of the Swedish legislation is that the precautionary principle should be implemented, not only by the competent government authorities, but also by anyone who undertakes whatever kind of action that may have a

potential impact on health or the environment. Obviously, most of these actors do not possess, and will never obtain, the scientific/technical competence required to undertake an adequate assessment to judge if the precautionary principle demands some type of action. When, for example, the purchasing departments of major retailers or the departments of the huge Swedish public sector decide on product acquisitions, they are supposed to make an assessment of potential health and environmental hazards. In most cases they actually try to do so, but here they more or less completely rely on the so-called 'OBS-listan', a long list of potentially hazardous chemicals published by KEMI. The profile of hazardous agents included on the list differs widely, from decidedly harmful compounds like arsenic salts and benzene, to practically innocuous substances, like many zinc compounds. The latter should, of course, not be dumped in rivers in large quantities, but are perfectly safe in most other contexts. The list carries an explanatory section that encourages the user to make some sort of risk assessment if the substances on the list are to be used.

However, because the purchasing departments lack the competence to do this properly, and also because of the pressure to carry products with 'green labels' (supposedly environmentally 'safe'), they mostly refuse to buy any product that contains a chemical that has been included on the KEMI list. The overall result has been the promotion of a number of consumer products of inferior quality in the name of an imaginary or negligible improvement in safety. Alternatively, products are marketed that contain substances not on the list, which are less well investigated and could even be more harmful. The new Swedish unified Environmental Code Act will surely enhance this undesirable development. The argument promoted by the defenders of this policy is, of course, that the market has to improve its (eco)toxicological competence. But this is unrealistic. Firstly, even the responsible government agency has only a handful of adequately trained experts suitable for this purpose. Secondly, in many cases when the producers have indeed been able to present a satisfactory risk assessment that substantially 'proves' their product to be 'safe' in spite of the fact that it contains a substance on the KEMI list, their arguments are rejected because 'industry cannot be trusted in such matters'.

The precautionary principle, the substitution doctrine and mosquito repellents

Apart from its use as a justification for otherwise baseless bans or severe restrictions on the use of chemical products, the precautionary principle is used to justify the application of the so-called 'substitution doctrine'. Current Swedish legislation explicitly states that if a hazardous chemical product can be replaced by a less hazardous alternative, such a substitution must be carried out.

Used with common sense this does not seem all that unreasonable. However, in the way the previous – and to some extent also the present – legislation has been implemented, almost any chemical product that fulfils certain criteria can be

subjected to a ban or severe restriction, irrespective of the actual or projected level of risk.

Consider the example of the mosquito repellents. A number of excellent substances were withdrawn on the basis of unsubstantiated claims that they were hazardous to health. They were subsequently replaced by considerably less efficient products, which were no doubt used in larger quantities in order to compensate for their inefficacy (or alternatively resulted in larger numbers of mosquito bites – an irritating thing even in a country without malaria and other mosquito-borne diseases).

Thus, bizarre consequences have resulted from the unfortunate combination of a reliance on the precautionary principle and the intrinsic properties (hazard) of a chemical. As Paracelsus pointed out in his treatise *Septem Defensiones,* (1537–1538): any substance can elicit a toxicological response provided that the dose is sufficiently high when administered by an adequate route. (This is often paraphrased as 'the dose makes the poison.') To what extreme extent the substitution principle must be applied in Sweden is illustrated by the following excerpt from the Government's commentary to the substitution principle:

> The product substitution principle means, that although a harmful substance or product is permitted per se, it must be avoided or – provided that the user can obtain the desired result – replaced by one that is less hazardous or completely harmless. Everyone who uses a chemical product or a biotechnological agent must appraise if the same result can be achieved by using an alternative chemical product or biotechnological agent that is less hazardous or completely harmless.

That there is, of course, no such thing such as a 'completely harmless' chemical product except in the imagination of Swedish legislators and the eco-warriors of the green movement, is a frightening token of an absolute disregard for realities:

> It should be observed, that this rule does not only apply to professional sale and use. When a car owner is going to wash and clean his car and buys a detergent for this purpose in a gasoline station, he must select a product that causes as little harm to the environment as possible, provided that it cleans his car.

When making this assessment, the poor car owner

> …must apply the precautionary principle in such a way that it takes not only factual risk into account, but also the (potential) risk.

It is, of course, not even remotely possible that any Swede could be indicted on the grounds of having made the wrong choice when selecting a detergent at a gas station, but the principle as such provides guidance when, for example, issuing regulations based on the Environmental Code. It is also important for the local administrations in the context of regulatory control.

Based on what can be described as a mere pamphlet referring to a possible carcinogenic action based on rodent studies – scandalously meagre documentary

support – Sweden introduced a total ban from 1996 for trichloroethylene (TRI). The European Commission, which was notified of the proposed regulation, pointed out to the Swedish Government on several occasions that the Commission considered this ban to be unjustified and in violation of Article 30 of the Treaty of Rome (Monti, 1996). While referring to Article 36 of the EU Treaty, which permits national governments to introduce exemptions from the free movement of products between EU member states based on the necessity to protect human health, the Swedish Government insisted on upholding the ban. But in response to pressure from the Commission certain exemptions were granted. One small enterprise that was refused exemption by KEMI appealed to the first administrative county court ('Länsrätten') which reversed the decision by KEMI citing Article 30 of the EU treaty. This Agency then appealed to the higher administrative court ('Kammarrätten'), and this court relegated the case to the European Court of Justice for guidance in the interpretation of the EU Treaty. After conducting hearings where the Government of Sweden was represented on the highest level, the Court pronounced its verdict in July this year (C-473/98; Kemikalieinspektionen and Toolex Alpha AB).

The court found that the Swedish regulations were in agreement with Article 36 of the Treaty of Rome, and upheld the Swedish ban, noting that the Commission had not yet made use of its power to propose Community measures specifically relating to trichloroethylene, and that exemptions from the ban could, in principle, be obtained. That being so, the Court held that Community law did not prevent a Member State from regulating the industrial use of trichloroethylene. The fact that recent human epidemiological studies had strengthened the suspicions that TRI probably is carcinogenic for humans, obviously had a major impact on the court's decision, and explicit reference was made to the substitution principle as defined by the relevant Council Directives on occupational health (89/391/EEC of June 12 1989, and 90/394/EEC of June 28 1990).

However, the verdict is extremely unfortunate from many points of view. It is deplorable that industry interests did not seem to have been adequately supported by a competent legal council. Thus, I found no evidence that the lawyer representing the enterprise in question ever brought up the critical issue of the actual level of risk, which is necessary in order to be able to judge if the Swedish regulations were proportionate or not to the risks involved. Only a few cases of kidney cancer were found in Germany as a result of massive exposures to TRI after World War II at a level that does not exist either in Sweden or in Germany nowadays. The Swedish competent authority for occupational health, which has publicly stated that the current threshold limit value of 20ppm for TRI provides adequate worker protection, was not even heard at the trial.

At the hearings, the Swedish Government falsely stated that the hygiene standards issued by the Swedish Occupational Safety and Health Agency, '…primarily dealt

with short-term protection against trichloroethylene.' (The trichloroethylene trial; draft for statement at the hearing on February 8, 2000; Working paper from the Department of Foreign Affairs, the EU Legal Secretariat).

Furthermore, in Sweden as well as in all other EU member states, a number of much more potent carcinogens are regularly used under controlled conditions in the working environment. Of equal concern is the fact that the Court paid no attention to the principles laid down by the European Chemicals Bureau in its Guidance documents in support of the Commission Regulation on Risk Assessment for Existing Substances (EC 1488/94). This detailed document explicitly states that the margin of safety (MOS) shall be established for existing chemicals based on actual or predicted risks. Only if ambient or expected exposures approach the level at which harmful effects can be expected to occur, will there be reasons for regulatory action. Instead, the Court emphasised the difficulties in establishing the threshold above which exposure to TRI poses a serious health risk to humans, and said that

> there was no evidence in the case which would enable the Court to hold that national legislation such as the Swedish legislation goes beyond what is necessary to provide effective protection of the health and life of humans.

Given a competent legal council for industry, it would have been fairly easy to demonstrate that the Swedish regulations were totally disproportionate to the objective of protecting the worker's health.

The severe restrictions posed on the use of certain heavy metals in Sweden provide other examples of the misuse of the precautionary principle. During the last decades, the levels of lead in the blood of Swedish children have been steadily decreasing (Strömberg et al., 1995) as a result of the phasing out of leaded gasoline. They are now similar to those found in totally unpolluted regions, like the Himalayas (Piomelli, et al., 1980).

Still, the Swedish regulators are resolutely determined to phase out items made of lead, such as automobile batteries, sinks for fishing, keels for sailing boats and many others. In June 2001, the Swedish Government notified EU and the World Trade Organisation (WTO) of its intent to ban the use of lead in shot and buckshot. Bullet ammunition containing lead may only be permitted on shooting ranges, under the condition that efficient retrieval of the used bullets can be guaranteed. This ban is intended to include Olympic competitions as well as all military purposes. Similar future intentions have also been publicised with respect to all uses of cadmium, including recyclable accumulators. Now, cadmium is always present in zinc and is obtained as by-product from the purification of zinc. If no sensible use can be found for cadmium, the producers will simply let this heavy metal remain in the zinc, and the result will be an extensive and diffuse emission of cadmium from corroding zinc that will be impossible to control (Nilsson, 1989).

For reasons such as those presented above, it is my opinion that the precautionary principle as defined by the Swedish legislation is unacceptable. Not only does it open the sluices for capricious regulatory action, but it also introduces a factor of arbitrariness that disrupts the functioning of a free market as well as inevitably inhibiting sound technical development. Delegating use of the precautionary principle down to the lowest level of decision makers in society represents, in my mind, a cowardly and unacceptable behaviour of a government in a modern democracy. Through our elected Parliament, government agencies have been trusted with the duty to regulate product safety and restrict use of those products too hazardous to be permitted on the market – a duty that under normal circumstances should not be forced upon the individual citizen, or even on the purchasing office of a department store chain.

In the proposal for new Swedish unified Environmental Code Act of 1998 to the Parliament, the Government repeatedly refers to the Rio Declaration of 1992. Now, how well does the Swedish interpretation actually agree with existing international concepts. Principle 15 states that:

> In order to protect the environment, the precautionary approach shall be widely applied by states according to their capability. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Here, due consideration must be taken of the second sentence of Principle 15, 'where there are threats of serious or irreversible damage'. This puts considerable restraints on when the principle should be applied – an important qualifier that the Swedish legislators have completely ignored. This type of restraint is even more clearly spelled out for chemicals. Thus, under 'Management-related activities', Chapter 19 (Environmentally sound management of toxic chemicals including prevention of illegal international traffic in toxic and dangerous products) of Agenda 21, 'banning or phasing out' by regulatory action is reserved for 'toxic chemicals that pose an unreasonable and (emphasis added) otherwise unmanageable risk to the environment or human health and those that are toxic, persistent and (emphasis added) bio-accumulative and (emphasis added) whose use cannot be adequately controlled.' I have no problems whatsoever with such a definition of the precautionary principle with respect to chemicals.

When Swedish administrators are relying on the precautionary principle to motivate far reaching regulatory actions, they obviously rely on an interpretation that also differs from that of the legal experts of the European Community. The Economic and Social Committee described the precautionary principle as

> an approach to risk management applied to cases where there is an unknown and potentially dangerous risk – pending scientific findings at a later stage.

However, when this Committee, and the Rio Declaration, mentions 'risks', these risks are of an entirely different level than envisaged by the Swedish interpreters of

the precautionary principle. The view taken by KEMI has prompted it to withdraw the most effective mosquito repellents from the market and is trying to do the same with lead in ammunition and lead sinks for fishing. The Economic and Social Committee thus writes that: 'the contemporary risk indictor is the notion of disaster', and further that:

> Today, the nature of risks has changed, with a shift from accidents to disaster. These include natural and climate related disasters, technological disasters and, increasingly, disasters with an impact on health.

I do not think that even the most fanatical of my colleagues would consider it a disaster for humanity if we continue to use lead sinks for fishing nets, or that the classical mosquito repellent US 622 with a safe record for use all over the world, to be permitted.

It has been widely realised that acceptance of an extremist interpretation of the precautionary principle such as is used by the Swedish government, could obviously prove to be seriously disruptive for society. As a result, the European Commission intends to establish a common definition and specific guidelines for the application of this principle, 'so that each country is no longer able to prescribe a definition of its own' in the words of the Economic and Social Committee, which also concluded that:

> It is essential for the European Union to reach, if possible, an international consensus on arrangements for applying the precautionary principle.

Instead of delegating the implementation of the precautionary principle to the buyers of household detergents, the Economic and Social Committee of the Commission insists that:

> 3.4. The precautionary principle is only the State's responsibility. Under this principle, the State must act in line with certain hypotheses. The precautionary principle also makes the State responsible for abstention of action.

Further:

> 3.5. State action will apply to the decision-makers concerned, but it is not up to them to make the first move. That is in any case impossible given the vagueness of the precautionary principle. How can a decision-maker reasonably determine what constitutes a risk of serious damage, an effective and proportional measure or economically viable cost?

The Swedish legislation puts the whole burden of proof on the manufacturer, importer, vendor or even user, to demonstrate that suspicions that their product will cause a risk to man and the environment are without grounds. Although recommended in some situations, the Commission and its Economic and Social Committee both reject the use of a reversal of the burden of proof as a general principle.

To my mind, the precautionary principle should be given a central position in guiding legislation for the protection of man and the environment, but in a much

more restricted sense than provided by the Swedish concept. In effect, the responsible contemporary chemical industry has for quite some time endorsed, as well as implemented, several aspects of the precautionary principle. Clearly, the precautionary principle should only be applied when there are sufficient grounds to believe that a serious or irreversible damage to health and environment will occur.

The first step of its implementation is to conduct a risk assessment, identifying available knowledge, and in case of data gaps, make reasonable assumptions given possible uncertainties. As stated by the Economic and Social Committee, this 'involves stepping up the drive to boost knowledge'. Measures based on the principle must be proportional to the chosen level of protection and therefore include a cost–benefit assessment with the intention of reducing the risk to an acceptable level.

Further, the urgency for taking preventive measures must be demonstrated. Given the fact that triggering the principle is based on various degrees of uncertainty, it is also necessary that measures based thereupon are provisional.

Last and not least, measures adopted on the basis of the precautionary principle must be subject to legal redress according to Community law.

Alternative means to develop product safety

My stark opposition to the Swedish interpretation of the precautionary principle certainly does not mean that I think producers or distributors a product should not have responsibility for product safety. The existing legal framework for product damage litigation provides adequate safeguards against negligent marketing of hazardous products, as well as against misuse, where certain verdicts can be based on failure to follow the precautionary principle. In Europe this development has been considerably strengthened by EU-directive 85/374/EEC associated with strict liability. In the verdicts of Colona Laigneier/ Societé Pasteur Vaccins of April 4, 1997 as well as that of Armelle Jeanpert / La Societé SmithKline Beecham SA of June 5, 1995, the French courts applied strict liability with reference to this directive even for pharmaceuticals. Within the rule of law, arbitration by the courts ensures a reasonable measure of protection of legal rights. Unfortunately, Sweden has been very reluctant to implement the EU directive on strict liability, and in addition, the shockingly low levels of damages awarded to the victims do not constitute much of a deterrent. On the other hand, this could easily be amended by a much needed legal reform in this area, possibly including the introduction of punitive damages.

The US Toxic Substances Control Act (TSCA) of 1976 mainly defines regulatory action for chemicals. Pesticides are regulated separately through the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The basis for intervention by the competent agency, USEPA, rests on 'the presence of an unreasonable risk of injury to health or to the environment' (TSCA, Sec. 6(a)).

No definition of the 'unreasonable risk' can be found in TSCA, but the House Report provides that, in general, such a consideration will involve

> balancing the probability that harm will occur and the magnitude and severity of that harm against the effect of proposed regulatory action and the availability to society of the benefits of the substance and mixture.

USEPA must consider the availability of substitute chemicals and the adverse societal effects of the proposed action, but cannot base its actions on 'mere conjecture or speculation'. Section 6(a) of TSCA also provides that the Administrator must utilise the 'least burdensome' requirement necessary to adequately protect against risk. The verdict of the Supreme Court (1980) provides a more concrete example of what constitutes a 'significant risk'. The court wrote:

> Some risks are plainly acceptable and others are plainly unacceptable. If, for example, the odds are one in a billion that a person will die from cancer by taking a drink of chlorinated water, the risk clearly cannot be considered significant. On the other hand, if the odds are one in a thousand that regular inhalation of gasoline vapours that are 2% benzene will be fatal, a reasonable person might well consider the risk significant and take the appropriate steps to decrease or eliminate it.

Although I have not referred to the precautionary principle in US laws and regulations for chemicals, the restrictions imposed on CFCs for the protection of the ozone layer provide an example that in practice this principle can, and has been, implemented in the US. Further, the USEPA has relied on a number of precautionary assumptions in assessing health risks that have resulted in a highly conservative estimate of potential health risks. Sometimes this has resulted in greatly exaggerated risk estimates, as has been the case for cancer risks from arsenic in drinking water

The future

I sincerely hope that some kind of consensus can be reached at the Community level that could ensure a common interpretation of the precautionary principle that is based on sound principles. Although assessment of hazardous substances in the EU may not always represent the ultimate wisdom, the outcome will at least be competitively neutral with respect to industry and trade inside the Community. The question remains, however, to what extent countries like Sweden and Denmark are in practice going to conform to Brussels on this issue.

It has been very discouraging that since Sweden joined the EU – and in contrast to what is the case, for example, in Finland – an increasing number of people favour Sweden's exit from the Union. With the exception of trade and the export industry, resistance to EU is particularly strong among the lower social classes, especially in the northern part of Sweden, but is also prominent in the bloated Swedish public sector. Fierce EU antagonism is almost universal among the politically organised environmental movement and the previous communist party. Since these two parties at the present command sympathies from a sizeable part of the electorate, and with

the dominating Social Democratic Party and the Centre Party sharply divided over the membership issue, the future of Sweden as a full member of the Community is full of question marks. This unfortunate situation was reflected by the fact that a large number of prominent enemies of EU were elected as Swedish representatives to the European Parliament. Apart from serious economic consequences, cancelling its EU membership will accelerate the ongoing marginalisation of Sweden among Western nations, where an increasing part of Sweden's industry opts to move its production base outside the country.

The present socialist governments in the EU are more or less in league with the radical green movement. The recent announcement in the newspapers that the Blair administration will issue health warnings on mobile phones because of risk of radiation damage to children under 15, despite an inquiry which found no adequate evidence that mobile phones are harmful, unfortunately demonstrates that the misuse of the precautionary principle is no longer limited to Sweden. When the EU contemplates the general introduction of a principle that, depending on its manner of implementation, could adversely affect innovation within and the development of European industry, it would be highly appropriate to consider the situation within other large economies of the world, primarily USA and Japan, and in the near future China, while keeping in mind the future competitiveness of the Community.

Bibliography

Brüning, T., Sundberg, A.G.M., Birner, G., Lammert, M., Bolt, H., Appelkvist, E.-L., Nilsson, R. and Dallner, G. **(**1999) **'**Glutathione transferase α as a marker for tubular damage after trichloroethylene exposure. *Arch. Toxicol*. **73**: 246–254.

Economic and Social Committee (2000) Comments to the European Commission with respect to implementing the precautionary principle *Official Journal of the European Community*, C 268/11 September 19.

Henschler, D., Vamvakas S., Lammert, M., Dekant, W., Kraus, B., Thomas, B. and Ulm, K. (1995) 'Increase incidences of renal cell tumors in a cohort of cardboard workers exposed to trichloroethylene'. *Arch. Toxicol*. **69**: 291–299.

International Programme of Chemical Safety (IPCS), 1993. 'Toxicological evaluation of certain food additives and naturally occurring toxicants; Solanine and chaconine.' WHO Food Additives Series Assessment No. 30, WHO, Geneva, 339–372.

Ministry of Social Affairs (1992) 'Cancer – Causes and Prevention', Report from the Swedish Cancer Committee. Taylor and Francis, London.

Monti, M. (1996) CEC, letter of October 9 to the Swedish Minister of Foreign Affairs.

Nilsson, R. and Sjöström, H. (1972) *Pillret (The Pill)*, Sjöström & Sjöström Publ. Co,. Stockholm.

Nilsson, R. (1988) Procedures and Safeguards for Notification and Handling of Hazardous Chemicals in India, Report to WHO South-East Asia Region, SEA/EH/391, April.

Nilsson, R. (1989) Cadmium – an Analysis of Swedish Regulatory Experience, Report to the OECD Chemicals Group and Management Committee, Paris, January.

Nilsson, R. Tasheva, M. and Jaeger, B. (1993) 'Why Different Regulatory Decisions When the Scientific Information Base is Similar? Part I – Human risk assessment'. *Regulatory Toxicology and Pharmacology* **17**, 292–332.

Nilsson, R. (1994) 'Problems in the Regulation of Carcinogenic Chemicals in an International Perspective – III Critical Assessment of Regulatory Approaches'. *Revista Internacional de Contaminacion Ambiental [México City].* **10**, 99–119.

Nilsson, R. (1998) Integrating Sweden into the European Union: Problems Concerning Chemicals Control. In: *The Politics of Chemical Risk – Scenarios for a Regulatory Future* [Bal., R., and Halffman, eds.], Kluwer Academic Publ., Dordrecht, 159–171.

Nilsson, R. (2000) Endocrine modulators in the food chain and the environment. *Toxicological Pathology* **28**, 420–431.

Nilsson, R. Environmental tobacco smoke revisited: the reliability of the data used for risk assessment. *Risk Analysis* in press.

Nilsson, R., Natarajan, A.T., Hartwig, A., Dulout, F., De la Rosa Duque, M.-E. and Vahter, M. (1999) Clastogenic effects and influence of inorganic arsenic on DNA-repair in mammalian systems In: *Metals and Genetics* (Sarkar, B., ed.). Kluwer Academic/Plenum Publishers, 21–40.

Piomelli, S., Corash, L., Corash, M.B., Seaman, C., Mushak, P., Glover, B., and Padgett, R. (1980) 'Blood lead concentration in a remote Himalayan population'. *Science* **210**, 1135–1137).

Rosén, C.-G., Ackefors, H.and Nilsson, R. (1966) 'Seed Dressing Compounds Based on Organic Mercury – Economic Aspects and Health Hazards'. *Svensk Kemisk Tidskrift* **78**, 8–19 *(Journal of the Swedish Chemists' Association).*

Sjöström, H. and Nilsson, R. (1971) *Thalidomide and the Power of the Drug Companies*, Penguin Books Ltd., London, also translated and published by Feltrinelli, Milano; Iwanami Shoten Publishers, Tokyo; Gustav Fisher Verlag, Berlin.

Strömberg, U., Schuetz, A., and Skerfving, S. (1995) 'Substantial decrease of blood lead levels in Swedish children 1978–94, associated with petrol lead'. *Occupational Environmental Medicine* **52**, 764–769.

Supreme Court (1980) Verdict in the case of Industrial Union Department, AFL-CIO v. American Petroleum Institute, 444 US 607, 639–642 (benzene).

Taubes, G. (1995) 'Epidemiology faces its limits'. *Science* **269**: 164–169.

Toth, B. and Erickson, J. (1986) 'Cancer induction in mice by feeding of the uncooked cultivated mushroom of commerce, Agaricus bisporus' *Cancer Res*. **46**, 4007–4011).

Global warming: from the frying pan into the fire?

Indur Goklany

Introduction

The precautionary principle, as interpreted by Article 3.3 of the United Nations Framework Convention on Climate Change, envisions using a global cost–benefit framework to design precautionary climate change measures (UNFCCC, 1992)[1]. Despite Article 3.3 being an integral part of the UNFCCC, more generic versions of the principle have sometimes been invoked as justification for going beyond 'no regrets' actions[2] to address the potential threat of human-induced climate change (IPCC, 1996a: 5, Perry, 1999) which would reduce greenhouse gas emissions beyond what might otherwise be achieved through secular (or normal) technological change or through reductions of economically inefficient subsidies. Under this argument, aggressive greenhouse gas control is viewed as a precautionary measure, similar to an insurance policy, to forestall surprises or potentially disastrous consequences (Perry, 1999).

Overlooked by this argument is the prospect that such an insurance policy itself might raise new (or aggravate existing) threats to human health or the environment (Cross, 1998, Adler et al., 2000, Goklany, 2000a). However, generic versions of the precautionary principle offer no guidance in instances where a measure, ostensibly designed to forestall uncertain public health and environmental problems, might itself add to the world's health and environmental burden, thereby offsetting, if not negating, the presumed benefits of that measure.

I propose to investigate whether it would be prudent to control GHGs beyond what would occur under 'no regret' actions. In the parlance of the insurance metaphor, I would, in effect, undertake a qualitative cost–benefit analysis of the insurance premium. This is what nearly all individuals or families do before purchasing insurance, whether it is for life, health or property. And, of course, the amount of insurance purchased (if any) is affected by alternative uses for these funds. Instead of using money, however, I will use a more qualitative

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[1] This formulation does not necessarily call for the framework to be quantitative.

[2] 'No regrets' actions are those that ought to be undertaken on their own merits, regardless of any benefits related to global warming.

assessment of the effects on public health and the environment as the basis for the cost–benefit calculus.

There is extensive and easily accessible literature addressing issues regarding whether and why climate might have changed in the past century or so, and how much and how fast it might change in the future (see, e.g., IPCC, 1996b, 2001a; Michaels and Balling, 2000; Philander, 2000; Singer, 1998). Accordingly, I will not focus on these issues in detail here except to note that there is poor correspondence between temperature trends as measured by satellite, radiosonde and surface instruments (IPCC, 2001a: 2; World Climate Report, 2001), and between trends in sea surface and air temperatures (Christy et al., 2001), neither of which have yet been resolved satisfactorily. These alternative data sets suggest that recent warming is less than reported by the IPCC (2001a: 1).

Some sceptics have also noted that the warming to date is substantially less than ought to have occurred if the estimates for the climate's sensitivity to GHG concentrations were accurate. To explain this discrepancy [see Michaels and Balling (2000) and IPCC (2001a) for the arguments], it has been suggested that some of the warming that ought to have occurred had been offset by cooling due to sulphates. Moreover, goes this counterargument, because developing countries are likely to impose more stringent SO_2 controls in the future (to reduce acidic deposition and sulphate formation), the sulphate cooling effect would be reduced, boosting future global warming (IPCC, 2001a).

The latest chapter in this ongoing argument is a recent study by Jacobson (2001) which suggests that past sulphate cooling should have been offset by greater heat absorption by dark soot formed during combustion of fossil fuels and forests worldwide. If this is indeed the case, we are back to where we started, i.e., the models overestimate climate sensitivity to GHG build-up. Also, a recent paper by Lindzen et al. (2001) gives greater credence to the contention that the treatment of clouds in present day models is flawed and overestimates warming significantly. This paper, based on satellite measurements over the tropical Pacific Ocean, indicates that as the ocean warms, the areal extent of cirrus clouds relative to cumulus clouds declines, which allows more heat to escape into the upper atmosphere, cooling the surface. In other words, cirrus clouds over oceans seem to act as a thermostat. No such mechanism is built into current models.

However, instead of dealing with the issues surrounding the physics of climate change, the following discussion focuses on the *impact* of climate change on

the basis that the fundamental reason why climate change is on the international policy agenda is its impact, rather than climate change *per se*. In fact, if climate were to change but have no impact, climate change would merely be a scientific curiosity worth investigating in its own right, but not as a public policy issue (Goklany, 1992). Further, I will address the potential impacts over the next several decades, rather than impacts that might occur after centuries or millennia of sustained – and drastic – climate change, such as the collapse of the West Antarctic ice sheet or the shutting down of the thermohaline circulation in the North Atlantic (IPCC, 2001a: 10–11).

Since at the time of this writing, the IPCC's full Third Assessment Report (TAR) has not yet been released, the projections of the impacts of climate change provided below are based on the IPCC's Second Assessment Report (SAR; IPCC, 1996a, 1996b, 1996c). Notably, while press reports have highlighted the statement from the IPCC Work Group I's latest *Summary for Policymakers* that the upper limit to the range of future climate change projections in 2100 has increased to 5.8°C (IPCC, 2001a: 8), they have overlooked the fact that the same report on the same page goes on to state that:

> On timescales of a few decades, the current observed rate of warming can be used to constrain the projected response to a given emissions scenario despite uncertainty in climate sensitivity. This approach suggests that anthropogenic warming is likely to lie in the range of 0.1 to 0.2°C per decade over the next few decades.…

In other words, if one accepts recent trend data from surface temperature measurements as valid – a proposition which, as was noted, many sceptics have challenged – then, according to the TAR itself, the likely change in temperature for the next few decades is not much different from what was estimated in the SAR. In fact, the TAR notes that climate sensitivity to an equivalent doubling of greenhouse gases has not changed much, and that the new estimate for sea level rise (0.09–0.88 metres, or 4–35 inches) is marginally lower than contained in the SAR (0.13–0.94 metres, or 5–37 inches) (IPCC, 2001a: 10). Thus, the 'likely' estimates of climate change impacts over the next few decades ought to be based on scenarios that correspond to globally averaged temperature changes of 0.1–0.2 °C per decade. In fact, the scenarios employed in most studies reported in the SAR exceeded that range (Goklany, 1998b, 2000a). Notably, the conclusions of the TAR with respect to future impacts seem to be qualitatively similar to those in the SAR, except that they seem more upbeat about timber supply increasing due to climate change (IPCC, 2001b: 4).

The net impacts of uncontrolled global warming

The net global and regional impacts of human-induced climate change (or global warming) are inherently uncertain. This is because projections of future impacts are based on a series of model calculations, with each succeeding model using as its inputs increasingly uncertain outputs of the previous model (Goklany, 1992, 1995a, 2000a; IPCC, 1996c).

First, future emissions of greenhouse gases (GHGs) have to be estimated using uncertain projections of future population, economic conditions, energy usage, land use and land cover. These emissions are themselves sensitive to climatic conditions and to atmospheric concentrations. Second, these emissions have to be converted into each GHG's atmospheric concentration. Third, these concentrations have to be used to determine future 'radiation forcing' which is then used (ideally) by coupled atmospheric–ocean models to project climatic changes (such as changes in seasonal temperatures and precipitation, seasonal highs and lows, and changes in diurnal variability).

These climatic changes should be estimated at relatively fine geographical scales. This is because geography itself is an important determinant of the climate. Moreover, the distribution and abundance of natural resources, which are the basis of most climate-sensitive natural and human systems, are spatially heterogeneous. But regardless of how much confidence one may have in the ability of climate models to estimate globally-averaged climatic changes, the finer the geographic scale, the more uncertain the results.

Uncertain location-specific climatic changes serve as inputs to simplified and often inadequate models that project location-specific biophysical changes (e.g. crop or timber yields). Then, depending on the human or natural system under consideration, the outputs of these biophysical models may have to be fed into additional models to calculate impacts on those systems. For example, estimates of crop yields in specific areas should serve as inputs for a model of the global agricultural system in order to estimate overall impact on food security.

Ideally, there ought to be dynamic feedback loops between several of the models in the entire chain of models, going from emissions to impacts estimates. For instance, the climate affects photosynthesis and respiration on the earth's surface which, in turn, will affect global CO_2 emissions. Therefore, there ought to be dynamic feedbacks from the impacts and climate models to the emissions models. But to ease calculations, these feedback loops are generally ignored or replaced by static inputs or 'boundary' conditions.

Thus, estimates of the impacts of global warming in any specific location at any particular time are probably even more uncertain than estimates of the globally-averaged temperature and/or precipitation. Moreover, net global impacts – because they are an aggregation of the various location-specific impacts – are also uncertain, although there may be some cancellation of errors. Nonetheless, the uncertainties are large enough that one cannot be confident either of the magnitude or, in many cases, even the direction of impacts. In other words, whether the net impacts are positive or negative. This is true not only for any specific geographic location, but also globally.

Moreover, for climate-sensitive systems or indicators that are affected by human actions, (e.g., agriculture, forests, land use, land cover, habitat loss and biodiversity) impact models should include socioeconomic models, which ought to – but often do not – fully incorporate secular changes in technology and 'automatic' adaptations, among other things. Failure to reasonably account for such technological change and human adaptability results in a substantial upward bias in the projected negative consequences of climatic change. Human ingenuity not only can mitigate adverse effects but also can harness positive consequences of climate change. The forecasting landscape is strewn with spectacular duds such as the Club of Rome's *Limits to Growth*, the Carter Administration's *Global 2000* report, or Paul Ehrlich's *The Population Bomb* because of failure to account for this factor (Frederick et al., 1994; Goklany, 1992, 1996, 2000a).

Regardless of the uncertainties surrounding the impacts, unless fossil fuel emissions from both developed and developing countries are curtailed drastically, a number of developments are likely.

Atmospheric carbon dioxide concentrations will most likely continue to rise

All else being equal, higher carbon dioxide concentrations mean greater productivity for agriculture, if not vegetation in general (IPCC, 1996c, Idso and Idso, 2000, Wittwer, 1995). And greater agricultural productivity means more food, which leads to better nutrition, which, in turn, ought to result in better health, less disease and lower mortality (Goklany, 1999a, 2001). The remarkable increases in global agricultural productivity and global food supplies per capita since the end of World War II – despite a much larger population – have been accompanied by substantial worldwide improvements in health, reductions in mortality rates, and increases in life expectancies (Goklany, 1998a, 1999a, 2001). Most of the credit for these achievements is generally assigned to agricultural, medical, and public health technologies and practices, economic development (which makes more productive and improved

technologies more affordable), and trade (which moves food surpluses to food deficit areas and generally stimulates both economic growth and diffusion of technology) (Goklany, 1995a, 1998a, 1998b, 1999b, 1999c). Nevertheless, some credit is due to the past increase in CO_2 concentrations and, perhaps, to any associated global warming (Wittwer, 1995, Nicholls, 1997, Goklany, 1998b).

Globally-averaged temperatures will be higher, but the degree of warming and its geographic distribution is uncertain

There ought to be greater warming in the higher latitudes, at night, and during the winter. In general this means, among other things, greater agricultural and forest productivity in the higher latitudes because of longer growing seasons, but it could increase heat stress and reduce productivity in the tropics (Goklany, 1992, IPCC, 1996c). Although the contribution of warming *per se* to the historical increases in global agricultural productivity is not yet known, growing seasons and forest productivity have been increasing in the northern latitudes due, perhaps, to a combination of higher night time temperatures during the winter and higher CO_2 concentrations (Myneni et al., 1997, Tans and White, 1998, Fan et al., 1998, Tian et al., 1998). Similarly, Magnuson et al. (2000) find that freeze dates for river and lake ice seem to be occurring an average of 5.8 days later compared with 150 years ago, while thawing dates are occurring an average of 6.5 days earlier compared with 100 years ago.

Globally-averaged precipitation may increase, although precipitation may decline in some areas

Also, the timing of rainfall may be altered. Increased precipitation does not necessarily translate into greater availability of moisture for growing crops and vegetation. In some areas, increased evaporation due to higher temperatures may, all else being equal, more than offset increased precipitation. On the other hand, the water-use efficiency of vegetation goes up with increasing carbon dioxide concentrations. Thus, it is very difficult to predict the amount of water needed to grow specific crops and other vegetation at any given location (IPCC, 1996c; 2001a: 8).

Although there has been no discernible increase in the rate of sea level rise over the past century due to global warming, it could conceivably accelerate in the future (IPCC, 1996b; 2001a: 6).

Altered patterns of temperature and precipitation combined with increasing CO_2 concentrations will cause some animal and vegetation species to migrate.

The ensemble of species or 'ecosystem' at any specific location today will, thus, be altered, as will the abundance of individual species at that location (Goklany, 1992, 1995a; IPCC, 1996c: 451–454; 2001: 8). But whether these changes constitute a net benefit or loss is unclear. Not only is the 'final' distribution of species uncertain, but there are also no criteria for establishing whether the change has resulted in a net loss or benefit to either humanity or the rest of nature. Proponents of GHG controls implicitly assume that any change is inherently detrimental, but this is more an article of faith than the product of a rational inquiry into aspects such as changes in net or gross productivity, or the mix and abundance of species.

In addition, the potential spread of vector-borne diseases in a warmer world has been raised as one of the major concerns regarding anthropogenic climate change. Some fear that vectors such as the anopheles mosquito – the carrier of malaria – could become more widespread with warming because a change in climate could alter the range and abundance of species (McMichael et al., 1996a, 1996b). Malaria was estimated to have killed 1.1 million people in 1999 (WHO, 2000). However, historical data indicate that the prevalence of these diseases depends less on their potential ranges than on an understanding of their causes and the public health measures taken to deal with the vectors and the diseases they spread. In fact, a recent National Academy of Sciences report notes that for such reasons the 'impact of climate change on human health is 'highly uncertain'' (*National Academies News*, 2001, based on National Research Council, 2001).

Malaria, cholera, and other diarrhoeal and parasitic diseases that were prevalent around the world during the last century, including in the United States and Western Europe, have been rolled back around the world (Howard, 1909; Porter, 1996; Goklany, 1999c; Reiter, 1996, 2000). Few recognize the toll these diseases took in the nineteenth century in today's developed countries. For instance, mainly because of cholera, yellow fever, typhoid, and various diarrhoeal and gastrointestinal diseases, the mean crude death rate (CDR) in New Orleans for a 30-year period between 1830 and 1859 was 60,000 per million (Smillie, 1952). By comparison, in 1990–1995, it was 44,600 per million for Rwanda – the nation with the world's highest CDR – and 8,800 for the United States (WRI, 1998). In, 1900, the cumulative death rate in the United States for typhoid, paratyphoid, various gastrointestinal diseases, and all forms of dysentery was 1,860 per million population (Goklany, 1996). Today, due to a host of public health measures, these diseases barely show up in current US statistics, accounting for a death rate of less than 5 per million (Rosenberg et al., 1996).

Thus, despite any warming that may have occurred, advances and investments in, and greater availability of, food, nutrition, medicine, and public health technology helped reduce infectious and parasitic diseases worldwide – particularly among the

young in developing countries. As a result, crude global death rate has dropped, which has pushed global life expectancy at birth from 46.4 in, 1950–55 to 64.3 years in, 1990–95 (WRI, 1998, Goklany, 2001). Today, climate-sensitive infectious and parasitic diseases are problems only where the necessary public health measures are unaffordable or have been compromised (Goklany, 1999c, 2000a; Reiter, 1996, 2000; Bryan et al., 1996).

It has been suggested that climate change may be a factor in the recent resurgences in vector-borne diseases in some parts of the globe (McMichael, 1996a, 1996b). Resurgences include malaria in Henan Province (China); malaria and dengue fever in the Americas; and cholera in Peru and Rwanda. However, increases in drug resistance; increased urbanization that can lead to unsanitary conditions that facilitate the spread of infectious diseases; premature discontinuation of control measures such as indoor spraying and use of impregnated mosquito nets; and faltering mosquito control and public health measures (e.g., reduction in DDT usage and chlorination) aggravated by poor nutrition seem to be more likely causes (Taubes, 1997; Pinheiro and Chuit, 1998; Sleigh et al., 1998; Besser et al., 1995; Roberts et al., 1997, 2000; Goklany, 2000a). In many developing countries, malaria has retreated, then advanced and, in some places, retreated once again as in-home malaria spraying was increased, then decreased, and increased again (Roberts et al., 1997, 2000).

Although extreme temperatures pose lesser public health problems than infectious and parasitic diseases, they too are a source of concern for public health since extreme heat (as well as extreme cold) can lead to death and sickness (McMichael et al, 1996a, Kilbourne, 1997a, 1997b). Gaffen and Ross (1998) reported that between, 1949 and 1995 the frequency of 'extreme heat stress events' increased for the United States. They suggested that continuation of this trend could pose public health problems in the future. However, analysis by Goklany and Straja (2000) of death certificate data from the Centers for Disease Control and Prevention (CDC, 2000), shows no upward trends in US crude death rates either due to excessive heat or excessive cold between 1979 and 1997, despite the ageing of the population (Goklany and Straja, 2000). One explanation for this lack of a trend is that technological changes might have overwhelmed any increased risks due to meteorological changes.

Despite the uncertainties associated with the impacts of climate change and the previously-noted tendency to systematically overestimate negative impacts,[3] I will in

[3] At the same time, by not properly accounting for technological change, these studies also underestimate the ability to take advantage of positive impacts.

the following assume that, by and large, the SAR's assessment of the future impacts of global warming are relatively sound. Those IPCC estimates suggest that in the absence of further GHG controls, over the next several decades the net impacts of global warming will be relatively small compared

with other environmental and natural resource problems facing the globe (see Table 1) (Goklany, 1998b, 1999a, 2000a).

In the absence of warming, global agricultural production would have to increase 83 percent from 1990 to 2060 to meet additional food demand from a larger and richer global population, according to one study relied upon by the IPCC's SAR (Reilly et al., 1996, Rosenzweig and Parry, 1994). Global warming may decrease production in developing countries but increase it in developed nations, resulting in a net change in global production of +1 or –2 percent in 2060.

Notably, the Rosenzweig and Parry study used a globally-averaged temperature change for 2060 that was higher than the IPCC's 'best estimate' for 2100 (Goklany, 1998b, 2000a). Also, it considered only a few of the potential adaptations that could be available in 2060 (or, for that matter, 2100). For instance, it did not consider the potential for productivity-enhancing techniques such as development of cultivars that can better tolerate drought, salt, and acidic conditions, and that can better take advantage of higher atmospheric CO_2 concentrations. These technologies are merely gleams in our eyes today, but could be realities six decades from now, perhaps as a result of bioengineering. O n the other hand, the analysis did not consider any change in the proportion of crops lost to insects and other pests. Of course, crop protection is an ongoing challenge for farmers everywhere with or without climate change (Goklany, 1998a, 1999b, 2000a).

Regarding forest and habitat, greater agricultural and other human demands may reduce forest cover by 25 percent or more by 2050 in the absence of any global warming, putting enormous pressure on the world's biodiversity (IPCC, 1996c: 95–129, 492–96). However, global warming alone – ignoring the beneficial effects of CO_2 on photosynthesis and water-use efficiency – may actually *increase* forest cover by 1 to 9 percent (IPCC, 1996c: 95–129, 492–96). The existing boundaries of current forest types would, almost certainly,

Table 1: Projected climate change impacts compared with other environmental problems

Climate-Sensitive Sector/Indicator	Year	Impact/Effect		
		Baseline, includes impacts of environmental problems other than climate change	Impacts of climate change, on top of the baseline	Impacts of Kyoto Protocol, relative to baseline*
Agricultural Production	2060 for socio-economic baseline >2100 for climate change	must increase 83% relative to1990	net global production would change –2.4% to +1.1%; but could substantially redistribute production from developing to developed countries	net global production would change -0.2% to +0.1%
Global Forest Area	2050	decrease 25-30(+)%, relative to 1990	increase in global forest area of at least 1%–9%	reduce the increase in global forest area
Malaria Incidence	2060	500 million	25 to 40 million additional cases	reduction in number of cases by 0.5%-
	2100	500 million	50 to 80 million additional cases	reduction in number of cases by 1%-1.6%
Sea Level Rise (SLR)	2060	varies	~ 25 cm (or 10 inches)	reduce SLR by 1 inch
	2100	varies	~50 cm (or 20 inches)	reduce SLR by 2 inches
Extreme Weather Events	2060 or 2100	unknown	unknown whether magnitudes or frequencies of occurrence will increase or decrease in any specific area	unknown

Sources: Goklany (1998b, 2000a), based on IPCC (1996b, 1996c). * Assumes that the Kyoto Protocol, if implemented, would reduce climate change and its impacts by 10 percent. See text.

shift poleward. *A priori*, there is no reason to believe this would lead to a diminution of global biological diversity in terms of the number of species or their abundance. It is worth noting that, often, wetter and warmer climatic conditions seem to harbour greater biodiversity, so long as sufficient water is available (Hawksworth et al., 1995, Huston, 1994).

By 2100, incidences of malaria (which may be thought of as a metaphor for climate-sensitive infectious and parasitic diseases) may increase by about 10 to 16 percent of the base rate in the absence of warming (IPCC, 1996c: 561–584). The increase may be half that in 2060 (Goklany, 1999c, 2000a). These increases, although small compared with the baseline rate, are nevertheless likely to be overestimates, because the analysis is based on the notion that warming will expand the geographical ranges of the responsible vectors. This notion has been disputed by some authorities on tropical diseases (Reiter, 1996, Dye and Reiter, 2000, Bryan et al., 1996, Taubes, 1997, Rogers and Randolph, 2000). They note that the range of vectors depends not only on temperature extremes, but also, among other things, on the timing, quantity and seasonality of precipitation and runoff.

Perhaps more importantly, the current ranges of these diseases seem to be dictated less by climate than by human adaptability (Goklany, 1998b, 2000a; Reiter, 2000; Dye and Reiter, 2000; Rogers and Randolph, 2000; NRC, 2001). In fact, despite any global warming that is supposed to have taken place over the past century (or more), many of the once-deadliest infectious and parasitic diseases (e.g., malaria, yellow fever and cholera) have been virtually eradicated in richer countries although they were once prevalent there (e.g., the US and Italy). This is because, in general, a wealthier society has better nutrition, better general health, and greater access to public health measures and technologies targeted at controlling these diseases (Goklany, 1992, 1995a, 1999a, 2000a, 2001). Also, given secular improvements in public health measures and technologies that ought to occur in the next several decades, and the rapid expansion in our knowledge of diseases and development of the institutions devoted to health and medical research, the importance of climate in determining the ranges of these diseases is likely to further diminish. Despite all these considerations, I have assumed in Table 1 that the estimates of 5–8% by 2050 or 10–16% by 2100 are robust.

Although, so far, there has not been any discernable increase in the rate of sea level rise over the last century, sea level may rise 3 to 19 inches by 2060 (with a ‘best estimate’ of 10 inches), and about twice that by 2100 (Warrick et al.,

1996). The global cost estimate for protecting against a 20-inch rise in 2100 is about $1 billion per year (Pearce et al., 1996) or less than 0.005% of global economic product (Goklany, 2000a).

Proponents of establishing GHG emission limits have also speculated that the frequency and intensity of extreme weather events may be increased by global warming, as would deaths and damages due to such events. But so far, there seems to be little evidence of that (IPCC, 2001a: 3, 9). In fact, despite any increased global warming during the past century, US data show that in the past decades, death rates due to hurricanes, floods, tornadoes, and lightning have declined 60 to 99 percent since their peaks (based on 9-year moving averages, see Figure 1) (Goklany, 1998b, 2000a). In addition, although US property losses due to floods and hurricanes increased somewhat in terms of 'real' dollars during the twentieth century because an increasingly larger and richer population had more property at risk, losses did not increase in terms of percentage of wealth (Figures 2 and 3) (Goklany, 1998b, 2000a). Finally, there seems to be little scientific basis for concluding that in the future, extreme events will be more frequent or more intense due to global warming (Henderson-Sellers et al.1998; IPCC, 1996b: 332-35; IPCC, 2001a: 3, 9).

Hence, stabilizing greenhouse gas concentrations immediately, even if feasible, would do little or nothing *over the next several decades* to solve those problems that are the major reasons for concern about warming, except, possibly, sea level rise (see Table 1). Specifically:

Land and water conversion will continue virtually unabated, with little or no reduction in the threats to forests, biodiversity, and carbon stores and sinks;

The feeding, clothing, and sheltering of a larger world population will not have been substantially advanced, if at all;

Incidence rates of infectious and parasitic diseases will be virtually unchanged;

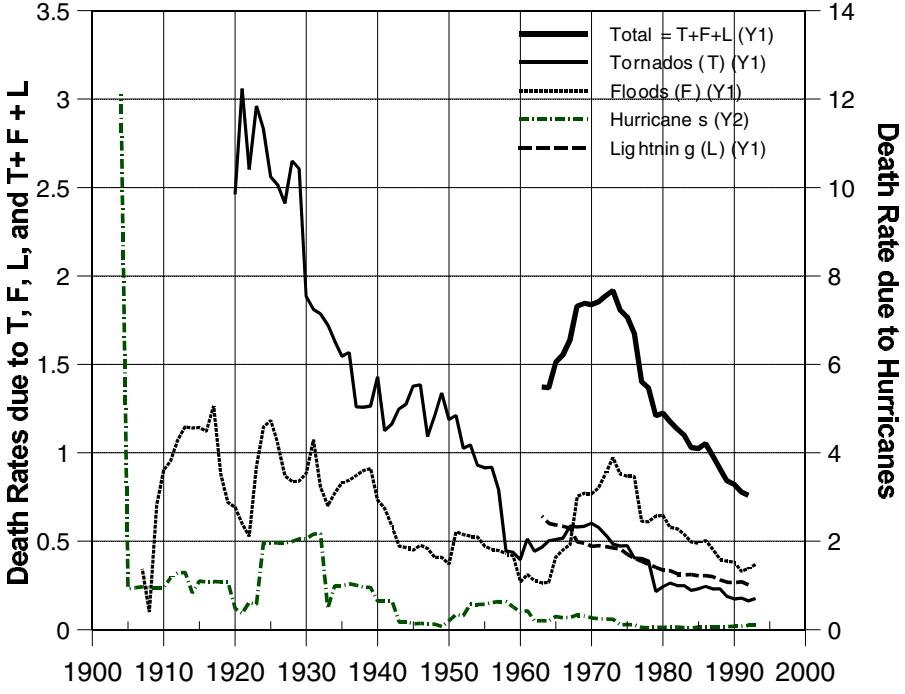
Poorer nations, which by virtue of their poverty are deemed to be most vulnerable to the adverse impacts of climate change, will continue to be vulnerable to all kinds of adversity, natural or man-made.

Thus, while global warming may be a serious problem in the long run, other environmental and health problems are likely to be much more urgent for the next several decades (Goklany, 1998b, 2000a).

Net impacts of aggressively forcing the pace of GHG emission reductions

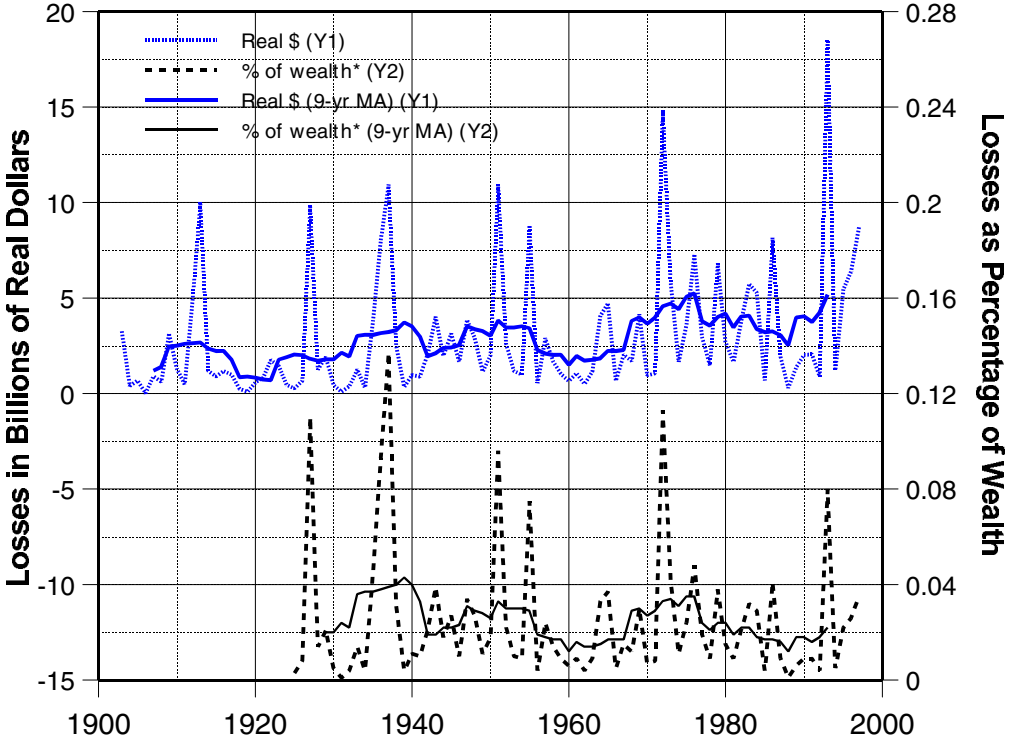
One approach to reducing greenhouse gases would be to let secular technological change run its course. In due time, that might reduce GHG emissions. Carbon intensities of currently developed countries (in terms of CO_2 emissions per GDP) have declined 1.3 percent per year since 1850 (Nakicenovic et al., 1998). Based on this century-and-a-half trend and the variety of technical options available for

Figure 1: Death rates due to tornadoes, floods, lightning and hurricanes
(per million population, 9-year moving average, 1900–1997)



Source: Goklany (1998b, 2000a)

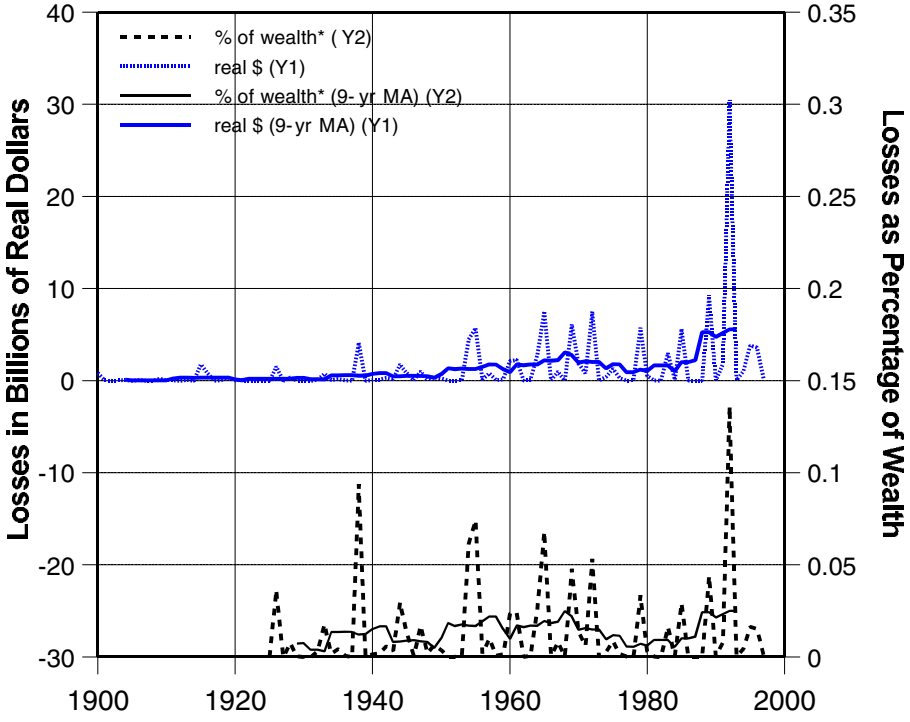
Figure 2: Property losses due to floods, 1903–1997



Note: Wealth measured as fixed reproducible tangible assets.

Source: Goklany (1998b, 2000a)

Figure 3: Property losses due to hurricanes, 1900–1997



Note: Wealth measured as fixed reproducible tangible assets.

Source: Goklany (1998b, 2000a)

providing energy services, Ausubel (1998) and Nakicenovic et al. (1998) suggest that economies will probably continue to decarbonise. Options include increased use of natural gas, nuclear, renewable energy sources, fuel cells and greater conservation.

But it takes more than the availability of technology to create technological change. It also takes financial means and institutional support (Goklany, 1992, 1995a, 1998a, 1999b). Fiscal resources for implementation will necessarily have to be generated through economic growth. The higher the economic growth rate, the higher the rate of decarbonisation of an economy (Nakicenovic et al., 1998). However, it is possible that, without additional stimulus, the rate of economic growth will outstrip the rate of secular decarbonisation of the economy, and CO_2 emissions might never stabilize.

Accordingly, proponents of GHG controls argue that the pace of decarbonisation should be accelerated. But the question is, how much and how fast should GHG emissions be reduced, who should reduce them, how should they be reduced, and what would be the impacts of any reduction requirements on global society and economy, and on the rate of climate change.

For instance, we could stabilize CO_2 concentrations at current levels. That, however, would require immediate emission reductions of *at least* 50 percent, because about 50 percent of the anthropogenic emissions of CO_2 are absorbed by the oceans and on land (IPCC, 2001a: 4). But like it or not, the world is fuelled largely by carbon-based energy sources. Therefore, the social and economic costs of GHG reductions of such a magnitude would be prohibitively high, unless one is willing to assume decarbonisation rates substantially greater than historically has been the case. In recognition of this, proponents of GHG controls argue for implementing a more modest first step, to serve as a down payment for wider and deeper emissions cuts down the road (Warrick, 1998).

Requiring developing countries to reduce GHG emissions would be particularly devastating to their prospects for economic growth, which is essential if they are to improve their lot socially, economically and environmentally (Goklany, 1992, 1995a, 2001). In order to shield the developing world from the high costs associated with GHG reductions, it has been suggested that, initially at least, GHG control requirements should be restricted to developed countries. Moreover, the energy infrastructure of developing countries is not only substantially more inefficient than that of developed countries, but it is also in greater need of expansion, and it makes sense to ensure that new capacity uses more efficient technology. Thus, it has been argued, it would be cheaper overall if developed countries discharged their ‘obligations’ to reduce GHG emissions

(or at least a portion of them) by paying for clean energy technologies in developing countries. Such transfer payments could be, it has been argued, justified under the emissions trading concept.

These various considerations were brought together in the Kyoto Protocol. This protocol, negotiated in December 1997 by the Conference of the Parties to the United Nations Framework Convention on Climate Change, (UNFCCC, 1992) requires 39 developed countries (including the US) to reduce CO_2 emissions by 2008–2012 to an average of 5.2 percent below their 1990 levels. But it does not specify any targets or timetables for developing countries. This is one of the reasons why the US Senate seems unlikely to ratify the Protocol soon. More importantly, the Protocol would reduce the amount of climatic change by 2100 by 3–10 percent, at most (Masood, 1997; Wigley, 1998; Malakoff, 1997). This modest reduction – probably within the noise level of natural variability – is a consequence of the inertia of the climate system, the Protocol's limited geographic coverage, and the fact that much of the future growth in greenhouse gas emissions is expected in exactly those countries that the Protocol would give a bye, i.e., developing countries.

Let us assume that the Kyoto Protocol would reduce the amount of climate change by 10 percent, which is at the high end of what is expected to occur by 2100 if the Protocol is implemented. Let us further assume, as an approximation, this would translate into a reduction in the *impacts* of climate change in each of the climate-sensitive sectors/indicators by 10 percent.[4] Then, according to the last column in Table 1, full implementation of the Kyoto Protocol would, over the next few decades, only marginally improve human or environmental well-being.

For instance, with respect to malaria, instead of the 550–580 million potential cases of malaria in 2100 (of which 500 million would occur even if climate were not to change) we would have 545–572 million cases. Such a relatively small reduction – 1 to 2 percent of total projected malaria burden in 2100 – might be justifiable if the costs were minor and if other, more effective opportunities for improving human and environmental well-being were all used up. But the cost of Kyoto, which its advocates conceive to be only a small

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[4] If one assumes that the impacts of climate change [$I(\theta)$] as a function of global temperature (θ) can be represented by a Taylor series, then this approximation would be valid at least to the first order, since the temperature change ($\Delta\theta$) due to human-induced climate change is small relative to the 'natural' temperature ($\theta 0$). See, e.g., Goldstein et al., (1999).

down payment toward much more deeper reductions in the future – is estimated to be in the hundreds of billions of dollars. An analysis done by MIT's Joint programme on the Science and Policy of Global Change (2000) estimates that in 2010, depending on the extent of emissions trading, the Protocol would cost between $90 billion and $116 billion (in 1995 US dollars). About 50 percent of these costs would be borne in the United States. Another analysis done by the Department of Energy in 1998 estimates that United States' annual GDP would be lowered $56 billion to $437 billion in 2010 (in 1992 dollars; EIA, 1998).

To put these costs into context, consider that, according to the World Health Organization, a life could be saved from malaria at a cost of $750–$2,500 (WHO, 1999: 56). The World Health Organization also estimates that annual expenditures of between $375 million and $1.25 billion could halve malaria's death toll of about 1.1 million per year (WHO, 1999: 56).

Similarly, Table 1 indicates that the global benefits of the Kyoto Protocol in terms of reducing impacts on other climate-sensitive sectors and indicators will also be quite modest, perhaps within the noise level, for the next several decades.

In addition, even if the relatively large transfer payments that developed countries might make to developing countries under the guise of emissions trading actually materialize – and there is no guarantee they will, since the populations of the former are not necessarily predisposed to such payments – the latter's' economies would not be fully shielded from the adverse impacts of the costs of the Protocol on the developed countries. This is because a significant portion of developing countries' economic output depends on their trade with developed countries. In 1995–97, exports accounted for 17.9 and 24.5 percent of the GDPs of the low- and medium-income countries, respectively (World Bank, 1999). The corresponding figures in 1990–92 were 14.2 and 21.7 percent, i.e. in the intervening five years, the share of GDP due to exports rose 26 and 13 percent, respectively. The rise was even more rapid for the least-developed countries, which increased 37 percent (from 13.1 to 17.9 percent of GDP). An analysis done during the earlier period indicated that a 1 percent drop in the GDP of developed countries translated into a $60 billion loss in the exports of developing countries (World Bank, 1992; Goklany, 1995a). It would undoubtedly be a larger figure today if adjustments were made for increased trade and inflation. Thus, some developing countries – particularly those that might not receive sufficient transfer funds – might have lower levels of economic development because of the Protocol, as would many of the developed countries targeted by the Kyoto Protocol.

When addressing the issue of economic development, it is critical to recognize that it is not an end in itself, but that it provides the means for numerous worthy ends, including the improvement of human well-being and the environment. Virtually every indicator of human well-being improves with the level of economic development (Goklany, 1992, 1999a, 2000a, 2001). Economic development, which creates wealth, helps increase food supplies per capita (Figure 4),[5] which reduces hunger and malnutrition. Economic development also makes basic public health services more available. Working together, improved health services and higher food supplies help reduce mortality rates. Thus, as levels of economic development increase, mortality rates decline and life expectancies increase, as we see in Figures 5 and 6.

In both those figures, improvements are most rapid at the lowest levels of economic development, that is, a uniformly small decline in incomes will have a larger negative impact in developing countries than it will in richer countries. Hence, aggressively forcing the pace of reductions could increase mortality rates and lower life expectancies, particularly in the developing countries (see also Cross, 1998). These costs may be balanced by the more speculative benefits associated with a reduction in the impacts of reduced warming, however, these are more distant in time.

Reduced economic development has other downsides from the perspective of public health and environmental quality. Firstly, lower levels of economic development are correlated with higher total fertility rates (see Figure 7)[6], which tends to push up population growth rates (Goklany, 1992, 1995a, 1999a, 2000a).

Secondly, it diminishes a society's adaptability to adversity, in general, and to climate change, in particular (Goklany, 1992, 1995a, 1999a, 2000a). This is because poorer societies have fewer resources available to research, develop,

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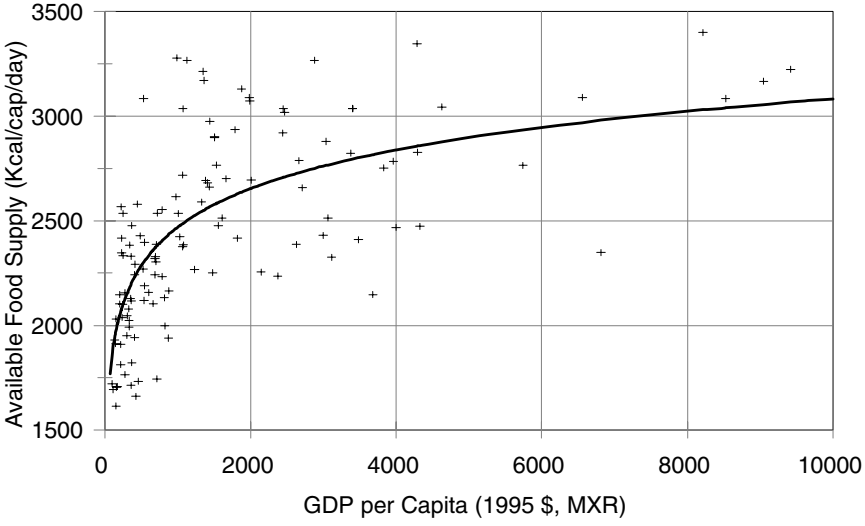
[5] The smoothed curve in Figure 4, taken from Goklany (2001), is fitted using a log-linear model. In this and subsequent figures, GDP per capita (or per capita income) is in 1995US dollars using the market exchange rate (MXR). N = 150 and R_2 = 0.63. The slope is significant at the 0.001 level. The scale on the x-axis is cut off at a GDP/capita of $10,000 to better illustrate the rapid change in available food supplies per capita per day at low levels of per capita income. The y-axis scale commences at 1,500 kcals/capita/day in recognition of the fact that the minimum energy needed by the body to perform basic activities at rest in a supine position, is in the general range of 1,300 to 1,700 kcals/day for adults with different characteristics (i.e. age, sex, height, body weight).

[6] The smoothed curve in Figure 7, taken from Goklany (2000b) is fitted using a log-linear relationship. N and R_2 are 148 and 0.55, respectively. The slope is significant at the 0.001 level. The x-axis scale is cut off at $20,000 per capita.

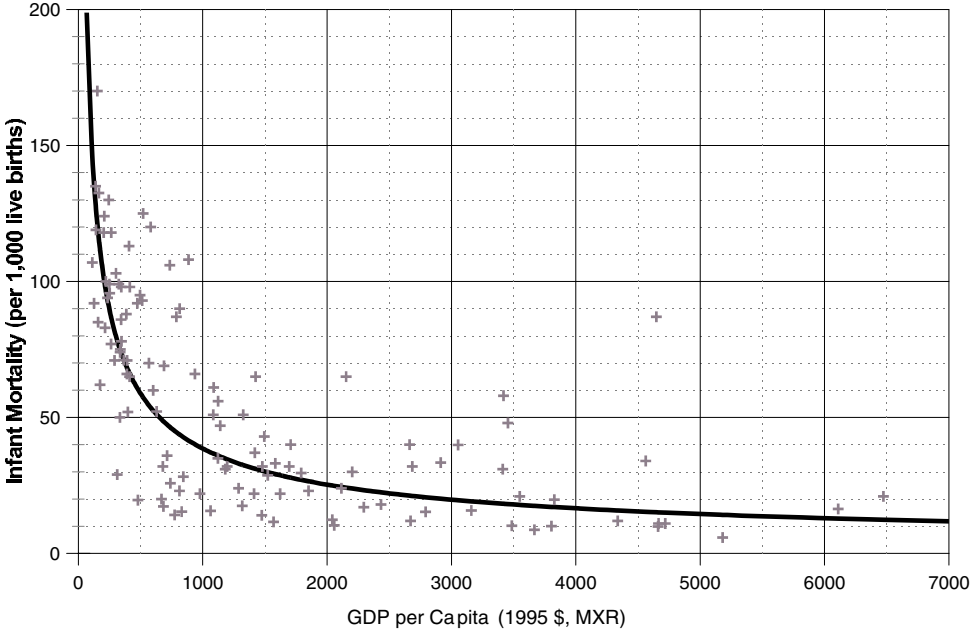
acquire, operate and maintain technologies that would help society better cope with problems as they arise, including unmet public health, environmental, and social needs. Richer societies are better able to afford higher levels of education that helps create and maintain human capital. This human capital is a prerequisite for

Figure 4: Available food supply v. GDP per capita, 1994



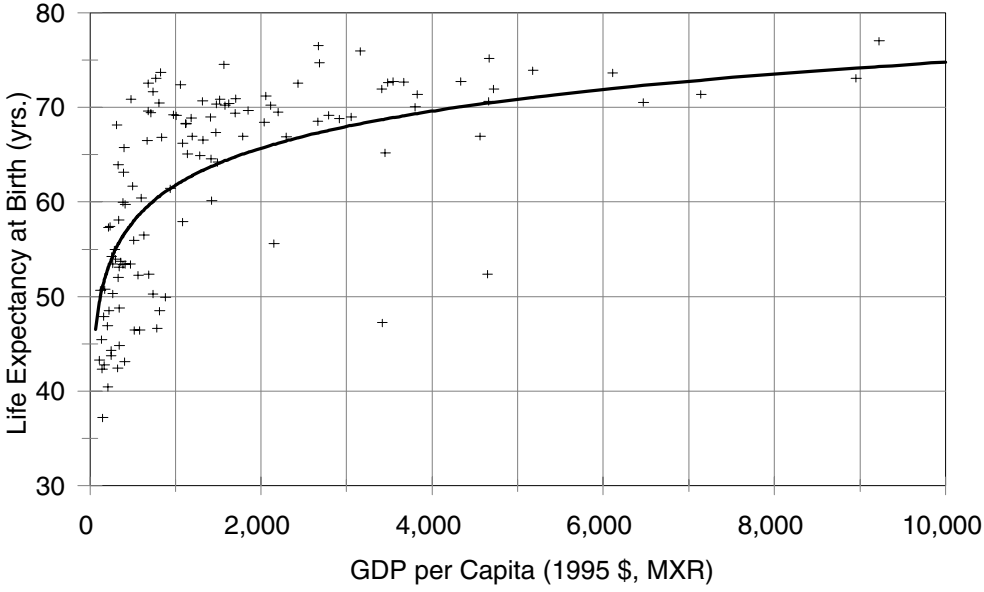
Source: Goklany (2000b)

Figure 5: Infant mortality v. GDP per capita, 1997



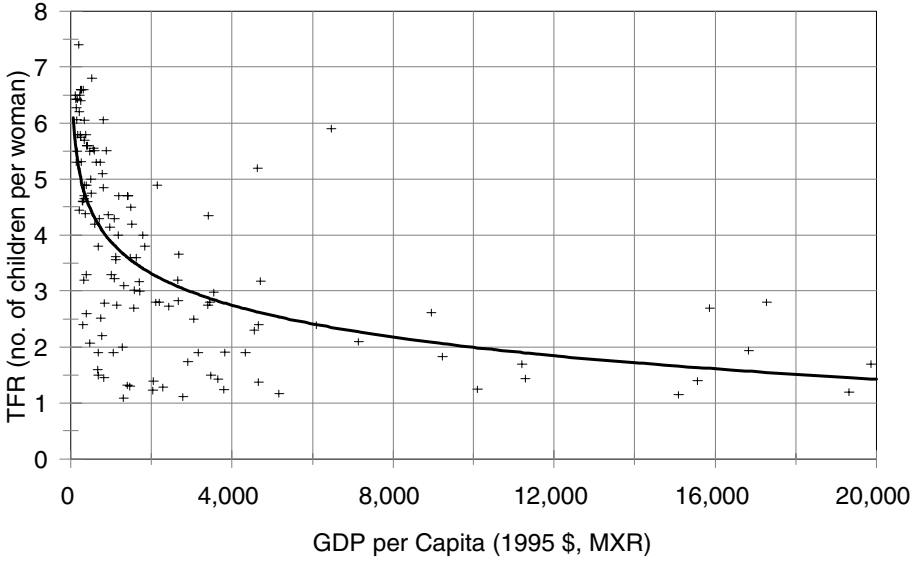
Source: Goklany (2000b)

Figure 6: Life expectancy v. GDP per capita, 1997



Source: Goklany (2000b)

Figure 7: total fertility rate v. GDP per capita, 1997



Source: Goklany (2000b)

bringing about and implementing these beneficial changes in technologies (Goklany, 2001). Thus, it is no surprise that access to safe water and sanitation increases with the level of economic development. Figure 8[7], for instance, shows that access to safe water increases with economic development and that, once again, improvement is most rapid at the lowest levels of development (Goklany, 2001).

Thirdly, a poorer society has lower crop yields (see Figure 9 for cereals)[8]. For any specific level of crop production, more habitat and forest have to be converted to cropland to compensate for lower yields. This puts greater pressure on biodiversity and reduces carbon stores and sinks. In fact, such conversion is the major threat to global biodiversity (Goklany, 1992, 1995a, 1998a; Wilcove et al., 1998). As was noted previously, it is hardly surprising that, between 1980 and 1995, forest cover in developing countries decreased by 190 million hectares (Mha) while it increased 20 Mha in the developed countries (FAO, 1997). Finally, efforts to substantially reduce GHG emissions could, over the next several decades, divert scarce resources from more urgent environmental and public health problems, e.g., control of malaria, climate-sensitive infectious or parasitic diseases (see Table 1).

As we have seen, future environmental and public health problems unrelated to climate change ought to substantially outweigh the adverse impacts of climate change for the next several decades. Thus, it would be counterproductive if, in the quest to make it easier to cope with the future adverse effects of climate change, we compromise the ability to cope with current public health and environmental problems that are more urgent today and are likely to remain so over the next few decades (Goklany, 2000a).

As an alternative to accelerating secular trends that would reduce GHG emissions, energy prices could be increased through taxes or through elimination of subsidies. Such price increases, however, could also have unintended consequences.

Firstly, the productivity of the agriculture sector would be reduced because that sector is heavily dependent upon oil and gas for running its farm machinery,

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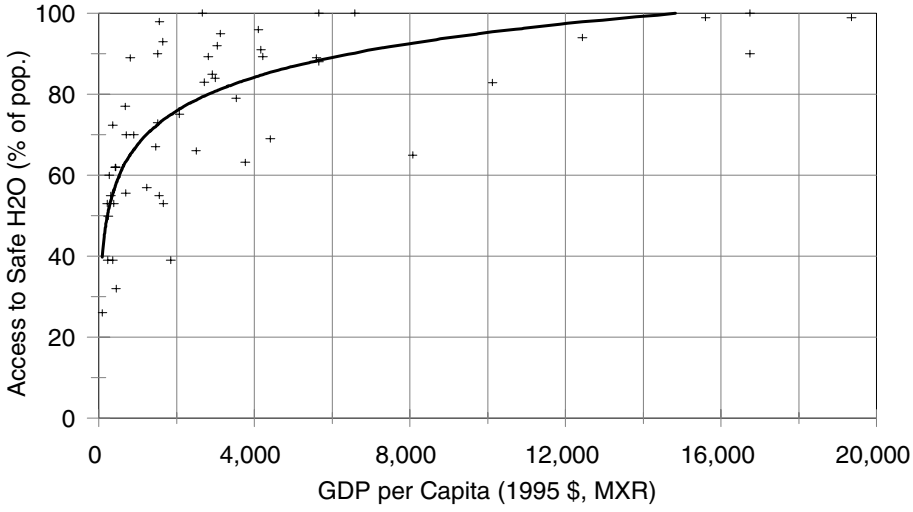
[7] The smoothed curve in Figure [8] is taken from Goklany (2000b). N is 51 for 1995. Because a number of countries were already at 100 percent in, 1995, a Tobit model was used for truncation at that level. The untruncated log-linear regression had R_2 of 0.55 for 1995. The slope is significant at the 0.001 level. This figure presents the data up to $10,000.

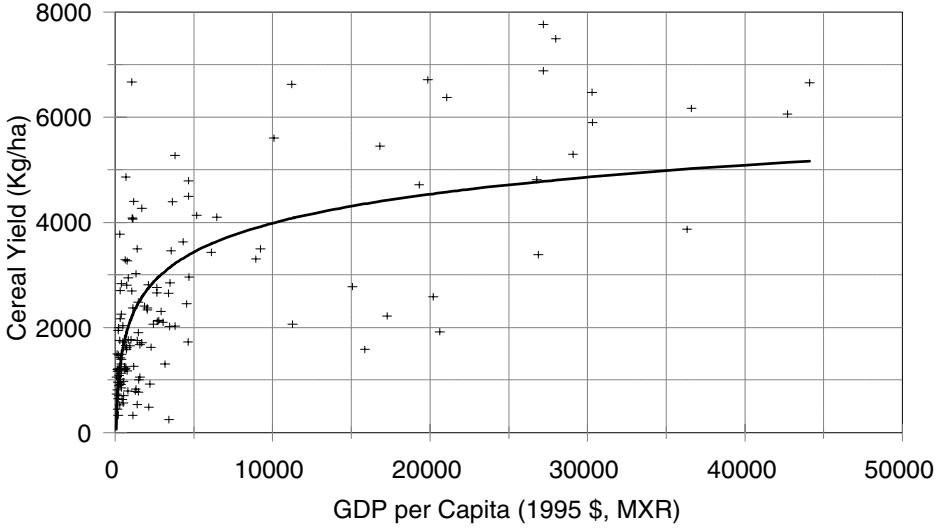
[8] The smoothed curve in Figure [9] is fitted using a log-linear relationship (Goklany, 2000b). N and R_2 are 138 and 0.49, respectively. The slope is significant at the 0.001 level.

Figure 8: Access to safe water v. GDP per capita, 1995



Source: Goklany (2000b)

Figure 9: Cereal yield v. GDP per capita, 1997



Source: Goklany (2000b)

producing inputs such as fertilizers and pesticides, powering irrigation systems and moving outputs from farms to markets. Thus, food production would decline and/or prices would rise. This is precisely what happened following the oil shocks of the 1970s (Pinstrup-Andersen et al., 1999: 21). In either case, food would be less accessible to those who are less well off, and hunger and malnutrition would increase, which, in turn, should increase rates of death and disease among those groups.

Secondly, an estimated 2.8 million people worldwide die annually because of indoor air pollution, mainly because of the burning of solid fuels (e.g., coal, wood, and dung) for heating and cooking in the home (WHO, 1997). Increasing fossil fuel prices would only make it harder for households using solid fuels to switch to cleaner, commercial fossil fuels.

Thirdly, increasing fuel prices would inhibit the operation of heaters in the winter and air conditioners in the summer, which could lead to greater sickness, if not mortality, due to cold and heat waves (Goklany and Straja, 2000).

Applying the precautionary principle to global warming

The above analysis indicates that forcing the pace of greenhouse gas controls over the next several decades could indirectly aggravate hunger and reduce public health services, either of which, separately or together, could increase mortality, particularly in developing countries. On the other hand, such a policy might reduce the putative public health and environmental consequences of any global warming that may occur. The latter effect will probably be minor compared with the former, at least for the next several decades. Thus, the precautionary principle argues against accelerating GHG reductions for the next few decades beyond what would occur due to secular improvements in technology (i.e., normal measures to reduce air pollution and energy-related costs) and removal of unjustified subsidies for energy and land use.

This argument is strengthened by the immediacy criterion because the problems due to forcing the pace of GHG reductions are likely to occur sooner than the negative effects of deferring such reductions. The argument is further bolstered by the uncertainty criterion because the negative effects of greater poverty are also more certain than the positive effects of reducing climate change.

Similarly, with respect to environmental consequences, the threats to habitat, carbon stores and sinks, and biodiversity due to added GHG controls ought, over the next several decades, to outweigh the potential negative impacts of global warming. Moreover, any reduction in economic growth would make it

that much harder to cope with adversities in general, whether they are connected to global warming or not.

Thus, there is no guarantee that forcing the pace of GHG controls will provide net global benefits for public health or, separately, for the environment, but there is a good likelihood that it may well worsen both. Therefore, one could argue that the precautionary principle requires that GHG reductions not be accelerated.

But there are counterarguments against deferring requirements to reduce GHG emissions.

Firstly, given that the impacts of climate change could be in addition to other environmental stresses on natural and human systems, climate change may be the straw that breaks the camel's back. Consider malaria, for instance. Because of climate change, malaria incidences in 2100 may climb from 500 million to 550–580 million (Table 1).

But there are at least two ways to address the problem of the last straw (Goklany, 1999c). The usual approach is to try to eliminate the last straw. This means trying to forestall climate change completely in order to wipe out the 50–80 million additional malaria cases projected for 2100. But we know that there will be some climate change even if atmospheric GHG concentrations could be stabilized immediately (a most unlikely occurrence).

Alternatively, we could lighten the overall burden on the camel's back, by removing several other straws to make room for that proverbial last straw, if and when it descends. This would also leave a margin for error. Accordingly, we could focus on reducing the total 550–580 million malaria cases that may occur in 2100 rather than concentrate only on the extra 50–80 million. If the baseline rate of 500 million is reduced by just 0.2 percent per year from now to 2100, this would more than compensate for any increase in malaria due to climate change. And a 0.02 percent per year reduction would exceed any improvements that might result from the Kyoto Protocol.

Moreover, considering that a million Africans die from malaria annually and that it costs $8 to save a life-year from malaria (McNeil, 2000), humanity would be better served if a billion dollars were spent now to reduce malaria (and other potentially climate sensitive diseases) in the immediate future rather than on spending tens, if not hundreds, of billions to limit climate change, which may or may not reduce the burden of disease decades from now. Moreover, the knowledge gained from escalating anti-malaria efforts now will stand humanity in good stead if climate change increases malaria incidence.

This strategy would provide more bang for the buck, and benefits to humanity will come sooner and more certainly. In effect, the first counter argument against deferring requirements for GHG controls is nullified by the adaptation and uncertainty criteria.

A second argument against deferring GHG reductions is the supposition that the impacts of climate change will be small relative to other public health and environmental problems facing the globe is based on net global impacts. This assessment ignores the fact that there will be regional winners and regional losers because of non-uniform geographical impacts of warming. In particular, developing countries may be the biggest losers because being poor, they are the least able to adapt.

Consider food security, for example. Developing nations already run food deficits. Their net imports of grain currently amount to about 10 percent of their production (FAO, 2001). These deficits will get worse in the future because the increase in their food demand is expected to outstrip the increase in agricultural productivity (Goklany, 1999c, Pinstrup-Andersen et al., 1999). Global warming is expected to further aggravate developing nations' food deficits though developed countries' surpluses are expected to increase further.

It is not necessary to require GHG reductions to address this issue, however. The potential increase in food deficits due to climate change can be addressed in exactly the same way as we address current imbalances in production (and differences in 'comparative advantage') today, namely, through trade. Trade allows surpluses to flow exogenously voluntarily to deficit areas (Goklany, 1995a, 1998a). But to expand such trade, developing countries will need to 'grow' the non-food sectors of their economies (Goklany, 2000a). Also, as noted previously, economic growth has other ancillary benefits for human well-being. Thus, the second counterargument against aggressively forcing the pace of GHG controls is also invalidated by the adaptation criterion.

A third counter argument is that although climate change may not be the most urgent problem facing the globe over the next several decades, because of the inertia of the climate system, it may be too late to do anything about warming by the time its impacts become urgent. In other words, climate change may not be as urgent as other environmental problems today and tomorrow, but it could be crucial the day after tomorrow. Table 1, however, suggests that even if there is a 50-year lead time to implement climate change controls, we have two or three decades of leeway before commencing any costly control actions (Wigley, 1997, Wigley et al., 1996, Ha-Doung et al., 1997). Moreover, as Table 1 indicates, even if we could solve the problem of climate change, most of the

critical underlying problems that placed climate change on the global policy agenda in the first place would still need to be addressed (Goklany, 1992, 2000a). So one might win the battle over climate change, yet lose the war for the planet's – humanity's and the rest of nature's – well-being.

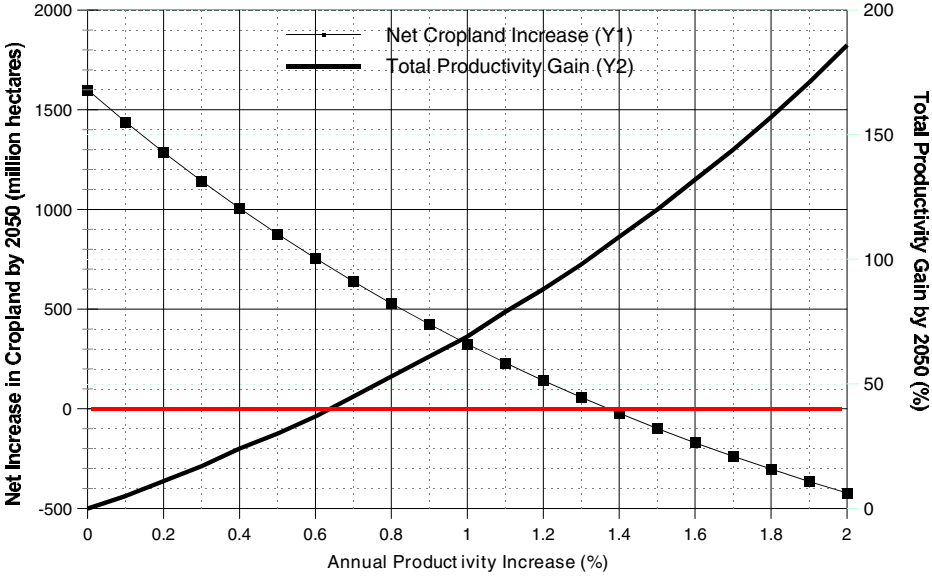
Consider forest and habitat losses. If human influence on climate change would be completely halted (an unlikely proposition), we could still lose 25 percent of global forest area because the increasing future human demand for food could increase pressures to convert additional habitat for agriculture (see Table 1) (Goklany, 2000a). Arbitrarily discounting (for the moment) the notion that climate change could increase global forest cover, as suggested by the IPCC (1996c; see Table 1), eliminating climate change would do little or nothing to reduce the major, imminent threats to global forests, ecosystems, biodiversity and loss of carbon sinks and stores. Similarly, if human-induced climate change is eliminated, the challenge of adequately feeding the world's future population will be practically undiminished.

So how do we solve the urgent problems of today and tomorrow, without compromising our ability to address the climate change problems of the day after?

There are two complementary approaches to addressing these multiple problems. Firstly, we can focus on fixing those current and urgent environmental problems that might be aggravated by climate change (Goklany, 1992, 1995a, 2000a). With respect to the problem of increasing forest and habitat loss, for instance, this means addressing its basic causes, namely, the increased demand for land and water to meet human needs for food, clothing, shelter, paper and other material goods. And to reduce such demand, we should attempt to produce as much food, timber and other products per unit of land and water as is possible in an environmentally sound manner. This will also help solve the problem of food security because it will increase food production and help keep food prices in check. In addition, reductions in land conversion to agriculture would help maintain global carbon stocks and sinks, thereby mitigating carbon emissions. Also by containing land costs, it would reduce costs for carbon sequestration or 'energy' farms (to produce fuel wood for energy), if they are ever needed (Goklany, 1998a, 1999b).

The trade-off between increasing land productivity and increasing land conversion is illustrated in Figure 10 for the case of agriculture (Goklany 1998a, 1999b). This figure plots this trade-off in terms of the net global conversion of habitat to cropland between 1997 and 2050 (on the left vertical axis) as a

Figure 10: Net habitat loss to cropland v. increase in agricultural productivity, 1997–2050



Source: FAO (2000) per Goklany (1998b, 2000a)

function of the annual increase in agricultural productivity during that period (on the x-axis). The right vertical axis translates the annual productivity increase

into the cumulative productivity increase over the 1997–2050 period. Although similar-looking graphs could be drawn for any scenario of population and food demand, the specific scenario illustrated in Figure 10 assumes that global population will rise to 8.9 billion in 2050 and that crop production per capita will grow at the same rate between 1997 and 2050 as it did between the early 1960s and late 1990s (Goklany 2000b). Based on these assumptions, the figure shows that, even if conventional agricultural productivity increases 1 percent per year, then by 2050 a net 325 million hectares (Mha) of existing forests or other habitat would have to be converted to new cropland – in addition to the 1,510 Mha of existing cropland (FAO 2000) – to meet future crop needs. This increase in cultivated area would inevitably increase the pressures on terrestrial biodiversity; emissions of greenhouse gases due to soil turnover and erosion, and use of nitrogenous fertilizers; water use; and nutrient and pesticide loadings in the environment. However, if through biotechnology or more conventional technologies productivity increases by, say, 1.5 percent per year (or a cumulative 120 percent between 1997 to 2050), then agriculture could return 98 million hectares of current cropland to the rest of nature (see Figure 10). An increase to 2 percent per year would return 422 million hectares (Goklany 2001b). Thus, small annual increases in agricultural (or forestry or other land-utilization) technologies translate in the long haul into substantial savings in land and habitat for the rest of nature. The same argument holds for wanting to increase the productivity of water use in agriculture.

To increase the productivity and efficiency of land and water use, we ought, for instance, to continue research and development on precision farming, integrated pest management and methods to reduce post-harvest and end-use crop and timber losses. Greater emphasis should also be placed on R&D to increase agricultural and forest productivity under less-than-optimal conditions, which might become more prevalent due to climate change, such as drought (due to higher temperatures and redistribution of precipitation), higher salinity (due to greater evaporation and saltwater intrusion in coastal agricultural areas) and higher carbon dioxide. Biotechnology, unless banned or greatly constrained, can play a crucial role in these endeavours. Genetically modified crops could also limit environmental damage associated with agriculture by reducing reliance on synthetic fertilizers and pesticides that eventually pollute both soil and water, and by increasing no-till cultivation, which, in turn, would further reduce soil erosion and water pollution. Moreover lower levels of soil erosion

and fertilizer use would reduce GHG emissions, specifically, CO_2 and nitrous oxide. Pound-for-pound, the latter is over 300 times more powerful a GHG than is CO_2.

The second approach to addressing the problems of today as well as those of the long term is to reduce the vulnerability of society in general by increasing its resilience to adversity, whatever its cause (Goklany, 1992, 1995a, 2000a). This can be accomplished by enhancing the mutually-reinforcing forces of technological change, economic growth and trade. As Figures 4–9 illustrate, virtually every indicator of human or environmental well-being improves with wealth. Poorer countries are hungrier and more malnourished; they have lower access to safe water and sanitation; and, consequently, their inhabitants suffer from higher mortality rates and live shorter lives. All this is because they are less resilient and more vulnerable to any adversity because they have fewer resources (fiscal as well as human capital) to create, acquire, and operate new and existing-but-underutilized technologies to cope with that adversity.

Poverty makes nations more vulnerable, not only to public health related problems, but also to environmental problems. It has already been noted that poorer nations have lower access to safe water and sanitation, as exemplified by Figure 8. They also use land less efficiently (see Figure 9) which translates into higher levels of habitat loss per unit of food produced and increased threats to biological diversity. Moreover, with respect to air quality and other, less critical environmental indicators, as I have argued elsewhere, richer is cleaner and anything that retards economic growth eventually retards environmental improvements (Goklany, 1995b, 1999b).

In essence, just as someone suffering from AIDS is less immune to an infectious disease, no matter what the infection, so is a poorer society less immune to adversity, no matter what its proximate cause. And just as AZT boosts the entire immune system of a person with AIDS, helping that person combat any infection, economic growth boosts the ability of society to combat any adversity, and not just the adverse impacts of climate change (Goklany, 1999c).

Economic growth enhances technological change, making society more resilient. In turn, technological change reinforces economic growth. Trade is also an integral part of boosting society's resilience. Not only does trade enable food and other natural resources to move from surplus to deficit areas voluntarily, but in so doing it also discourages exploitation of marginal resources. It also helps disseminate new technologies and bolster economic growth (Goklany, 1995a, 1995b).

To summarize, a comprehensive application of the precautionary principle points to caution over the next few decades in reducing GHG emissions; otherwise a more aggressive strategy could retard increases in global wealth, which could lead to greater hunger, poorer health and higher mortality, as well as retard progress toward environmental improvements in terms of safe water, sanitation, reduced habitat loss, and lowered threats to biodiversity. Specifically, the precautionary principle argues against forcing the pace of GHG controls beyond what would occur with secular improvements in technology. The principle argues, instead, for putting greater emphasis on research into the consequences of climate change; on solving current problems that may be worsened by climate change; on enhancing society's adaptability; reducing society's vulnerability to environmental problems by strengthening the institutions underpinning the mutually-reinforcing forces of technological change, economic growth, and trade. These institutions, which co-evolve, include free markets, secure property rights, honest government and predictable public policies.

In addition, enhancing adaptability and reducing vulnerability will raise the thresholds at which greenhouse gas concentrations become more 'dangerous'. This would be quite consistent with the United Nations Framework Convention on Climate Change's 'ultimate objective' which, according to its Article 2, is to prevent anthropogenic climate change from becoming 'dangerous,' however that term may be defined (UNFCCC, 1992, Goklany, 2000a). And, in turn, that would reduce the social and economic costs of GHG controls.

Conclusion

The precautionary principle has been invoked to justify a policy of aggressive GHG emission controls. However, this justification is based upon a selective application of the precautionary principle. It takes credit for the potential adverse effects of climate change that it would reduce, but ignores any adverse consequences that it might generate or perpetuate. The justification also overlooks any potential positive effects of climate change that might have to be foregone.

By slowing economic growth and/or increasing energy prices, crash efforts to significantly slow the increase in GHG atmospheric concentrations in the short- to medium-term could, in the final analysis, decrease overall access to food and delay improvements in public health. Poorer segments of society, especially in the developing world, would be most adversely affected. Contrary to claims that such a policy would be precautionary, it would, in fact, increase overall risks to public health and the environment. Thus, aggressive control policies

(such as the Kyoto Protocol) might – perversely – throw the world, particularly the developing world, from the frying pan into the fire. This would be particularly ironic because one of the arguments for taking aggressive steps to reduce climate change now is that its impacts would be worse for developing countries because they cannot easily afford adaptive measures and technologies.

The precautionary principle properly applied, with full consideration of all the public health and environmental consequences of action and inaction, argues for substantially different policies.

Specifically, the precautionary principle argues against GHG emission reduction requirements in the next few decades if they go beyond secular improvements in technology and elimination of unjustified energy subsidies. Aggressive GHG controls are likely to retard economic development worldwide, which would lead to greater hunger, poorer health, and higher mortality, especially in developing countries.

The precautionary principle also argues against raising oil and gas prices because that would reduce food availability, as well as slow down the abandonment of solid fuels for heating and cooking in the developing world, thus delaying reductions in mortality from indoor air pollution. Such requirements could also reduce crop yields and increase land conversion, habitat loss, and threats to biodiversity.

The precautionary principle argues for directly solving current urgent problems that may be aggravated by climate change. If we are truly concerned about malaria or malnutrition, we should expend our scarce resources (human and capital) to address these problems today. This would produce immediate and substantial benefits today, rather than several decades hence. On the other hand, reducing greenhouse gases today, if it does any good at all, won't produce significant benefits for several decades.

The precautionary principle argues for directly solving current urgent problems that would simultaneously reduce GHG concentrations in the atmosphere. This includes reducing unnecessary subsidies for energy and other natural resources, which only encourage overexploitation of marginal resources. Similarly, increasing agricultural productivity would increase food production and reduce hunger, while reducing habitat conversion, soil erosion and any associated loss of carbon stores and sinks.

The precautionary principle argues for increasing society's adaptability and decreasing its vulnerability to environmental problems in general and climate

change in particular. These objectives could be achieved by bolstering the institutions that are the foundations of the mutually-reinforcing forces of technological change, economic growth and trade. These institutions include free markets, secure property rights, honest bureaucracies and governments and predictable public policies. Moreover, consistent with the precautionary principle and the UNFCCC's 'ultimate objective', enhancing adaptability and reducing vulnerability will raise the thresholds at which greenhouse gas concentrations become 'dangerous'. These efforts would also reduce the overall cost of whatever controls may be ultimately necessary.

The precautionary principle argues for continued research and development into the science, impacts, economics and policy analysis of climate change, as well as continued monitoring of climate change and its impacts, so as to forestall nasty surprises in case the rates accelerate, or the impacts come sooner or are worse than anticipated.

The precautionary principle argues for continued research and development into alternative energy sources and other methods of limiting the build-up of GHG concentrations in the atmosphere, including, as insurance, exotic approaches such as iron fertilization of oceans, just in case a quick fix becomes necessary.

Finally, some also view aggressive GHG emission reductions today as a form of insurance. But, as shown above, the world cannot afford the premium for this particular policy. It would make little sense for a family to purchase an insurance policy with a premium large enough to jeopardize the breadwinner's ability to put petrol in the car used to get to work to keep the family clothed, fed and sheltered. On the other hand, the truly precautionary policies suggested in this paper would help humanity continue to progress while limiting its demands on the rest of nature.

References

Adler, Jonathan, et al., 2000. *Greenhouse Policy Without Regrets*. Washington, DC: Competitive Enterprise Institute.

Ausubel, J. H., 1998. 'Resources and Environment in the 21st Century: Seeing Past the Phantoms' *World Energy Council Journal*, July, pages 8-16.

Besser, R. E., et al., 1995. Prevention of Cholera Transmission: Rapid Evaluation of the Quality of Municipal Water in Trujillo, Peru. *Bol Oficina Sanit Panam* 119 (3):189-94.

Bryan, J.H., D. H. Foley and R. W. Sutherst, 1996. Malaria Transmission and Climate Change in Australia. *Medical Journal of Australia* 164: 345–347.

(CDC) Centers for Disease Control and Prevention, 2000. WONDER database, 2000. Available at wonder. cdc.gov.

Christy, J. R., et al., 2001. Differential Trends in Tropical Sea Surface and Atmospheric Temperatures Since 1979. *Geophysical Research Letters* 28: 183–186.

Cross, Frank B. 1998. *Could Kyoto Kill? The Mortality Costs of Climate Policies*. Washington, DC: Competitive Enterprise Institute.

Dye, Chris, and Reiter, Paul., 2000. Climate Change and Malaria: Temperatures Without Fevers. *Science* 289: 1697-1698.

Energy Information Administration, 1998. *What Does the Kyoto Protocol Mean to U.S. Energy Markets and the U.S. Economy*. SR/OIAF/98-03(S). Washington, DC: EIA.

Fan, S. et al., 1998. A Large Terrestrial Carbon Sink in North America Implied by Atmospheric and Oceanic Carbon Dioxide Data and Models. *Science* 282: 442–446.

(FAO) Food and Agricultural Organization. 1997. *The State of the World's Forests 1997.* FAO: Rome.

(FAO) Food and Agricultural Organization, 2001. *FAOSTAT Database*. <apps.fao.org>. Visited March 3, 2001.

Frederick, Kenneth M., Indur M. Goklany, and Norman J. Rosenberg, 1994. Conclusions, Remaining Issues, and Next Steps. *Climatic Change* 28: 209–219.

Gaffen, D. J. and R. J. Ross, 1998. Increased Summertime Heat Stress in the U.S. *Nature* 396: 529–530.

Goklany, Indur M., 1992. *Adaptation and Climate Change*. Paper presented at the Annual Meeting of the American Association for the Advancement of Science, Chicago, February 6–11, 1992. Available from author.

Goklany, Indur M. 1995a. Strategies to Enhance Adaptability: Technological Change, Economic Growth and Free Trade. *Climatic Change* 30: 427–449.

Goklany, Indur M., 1995b. Richer is Cleaner: Long Term Trends in Global Air Quality. In: Ronald Bailey, ed. *The True State of the Planet*. New York: Free Press, pp. 339–377.

Goklany, Indur M., 1996. Factors Affecting Environmental Impacts: The Effects of Technology on Long Term Trends in Cropland, Air Pollution and Water-related Diseases. *Ambio* 25: 497–503.

Goklany, Indur M. 1998a. Saving Habitat and Conserving Biodiversity on a Crowded Planet. *BioScience* 48: 941–953.

Goklany, Indur M., 1998b. The Importance of Climate Change Compared to Other Global Changes. In: Proceedings of the Second International Specialty Conference on Global Climate Change: Science, Policy, and Mitigation/Adaptation Strategies, Crystal City, VA, October 13–16, 1998. Sewickley, PA: Air &Waste Management Association, 1024–41.

Goklany, Indur M., 1999a. *The Future of Industrial Society*. Paper presented at the International Conference on Industrial Ecology and Sustainability, University of Technology of Troyes, Troyes, France, September 22–25, 1999.

Goklany, Indur M., 1999b. Meeting Global Food Needs: The Environmental Trade-offs Between Increasing Land Conversion and Land Productivity. *Technology* 6: 107–130.

Goklany, Indur M., 1999c. Richer is More Resilient: Dealing with Climate Change and More Urgent Environmental Problems. In: R. Bailey, ed. *Earth Report 2000, Revisiting the True State of the Planet*. New York, NY: McGraw-Hill, pp. 155–187.

Goklany, Indur M., 2000a. Potential Consequences of Increasing Atmospheric CO_2 Concentration Compared to Other Environmental Problems. *Technology* 7S: 189–213.

Goklany, Indur M., 2000b. *Applying the Precautionary Principle to Global Warming*. St. Louis, MO: Center for the Study of American Business, Washington University. Policy Study 158.

Goklany, Indur M. 2001. *Economic Growth and the State of Humanity*. Bozeman, MT: Political Economy Research Center. Policy Series 21.

Goklany, Indur M., and Soren R. Straja. 2000. U.S. Death Rates due to Extreme Heat and Cold Ascribed to Weather, 1979-1997. *Technology* 7S: 165–173.

Goldstein, Larry J., David C. Lay, and David I. Schneider. 1999. *Calculus and its Applications*. Eighth edition. Upper Saddle River, NJ: Prentice Hall.

Hawksworth, D. L., et al., 1995. Magnitude and Distribution of Biodiversity. In: V. H. Heywood et al., eds. *Global Bioiversity Assessment.* Cambridge University Press, Cambridge (UK), pp. 107–192.

Ha-Duong, M., M. J. Grubb, and J.-C. Hourcade, 1997. Influence of socioeconomic inertia and uncertainty on optimal (sic) CO_2-emission abatement. *Nature* 390: 270-273.

Henderson-Sellers, Ann, et al., 1998. Tropical Cyclones and Global Climate Change: A Post-IPCC Assessment. *Bulletin of the American Meteorological Society* 79: 19–38.

Howard, L. O., 1909. Economic Loss to the People of the United States through Insects that Carry Disease. *National Geographic* 20: 735–749.

Huston, Michael A., 1994. *Biological Diversity*. Cambridge, UK: Cambridge University Press, pp. 30–35

Idso, C.D. and Idso, K.E., 2000. Forecasting World Food Supplies: The Impact of the Rising Atmospheric CO_2 Concentration. *Technology* 7S: 33-56.

(IPCC) Intergovernmental Panel on Climate Change, 1996a. *Climate Change 1995: The Economic and Social Dimensions of Climate Change*. Cambridge, UK: Cambridge University Press.

(IPCC) Intergovernmental Panel on Climate Change, 1996b. *Climate Change 1995: The Science of Climate Change.* Cambridge, UK: Cambridge University Press.

(IPCC) Intergovernmental Panel on Climate Change, 1996c. *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change.* Cambridge, UK: Cambridge University Press.

(IPCC) Intergovernmental Panel on Climate Change, 2001a. Summary for Policymakers: IPCC WGI Third Assessment Report.

(IPCC) Intergovernmental Panel on Climate Change, 2001b. Summary for Policymakers: IPCC WGII Third Assessment Report.

Jacobson, Mark Z., 2001. Strong Radiative Heating Due to Mixing State of Black Carbon in Atmospheric Aerosols. *Nature* **409**: 695–697.

Joint Program on the Science and Policy of Global Change, 2000. *Multi-gas Strategies and the Cost of Kyoto*. Climate Policy Note 3.

Kilbourne, E. M. Cold Environments, 1997a. In: E. K. Noji, ed. *The Public Health Consequences of Disasters*. New York, NY: Oxford University Press, pp. 270–286.

Kilbourne, E. M., 1997b. Heat Waves and Hot Environments. In: E. K. Noji, ed. *The Public Health Consequences of Disasters*. New York, NY: Oxford University Press, pp. 245–269.

Lindzen, Richard S., Ming-Dah Chou, and Arthur Y. Hou, Does the Earth Have an Adaptive Infrared Iris?. *Bulletin of the American Meteorological Society* **82**: 417-432.

Magnuson, John J. et al., 2000. Historical Trends in Lake and River Ice Cover in the Northern Hemisphere. *Science* **289**: 1743-1746.

Malakoff, D., 1997. Thirty Kyotos Needed to Control Warming. *Science* **278**: 2048

Masood, E., 1997. Kyoto Agreement Creates New Agenda for Climate Research. *Nature* **390**: 649–50.

McMichael, A. J., et al., 1996a. Human Population Health. In: IPCC. 1996c. *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change*. Cambridge, UK: Cambridge University Press, pp. 561–584.

McMichael, A. J., et al., eds. 1996b. *Climate Change and Human Health*. Geneva: World Health Organization.

McNeil, Jr., Donald G., 2000. Selling Cheap Generic Drugs, India's Copycats Irk Industry. *The New York Times*, 1 December 2000: A1, A14

Michaels, Patrick, and Robert Balling, 2000. *The Satanic Gases: Clearing the Air About Global Warming*. Washington, DC: Cato Institute.

Myneni, R. B. et al., 1997. Increased Plant Growth in the Northern High Latitudes. *Nature* **386**: 698–702.

Nakicenovic, N., Grübler, A., and McDonald, A., (eds.) 1998. *Global Energy Perspectives*. Cambridge: Cambridge University Press.

(NRC) National Research Council 2001, *Under the Weather: Climate, Ecosystem, and Infectious Disease*. Washington, DC: NRC *(National Academies News*. 2001. 'Impact of Climate Change on Human Health Is Highly Uncertain' News Release, 2 April 2001.)

Nicholls, Neville, 1997. Increased Australian Wheat Yield Due to Recent Climate Trends. *Nature* **387**: 484–485.

Pearce, D. W., et al., 1996. The Social Costs of Climate Change: Greenhouse Damage and the Benefits of Control. In: IPCC. 1996a. *Climate Change 1995: Economic and Social Dimensions of Climate Change.* New York NY: Cambridge University Press, p. 191.

Perry, John S., 1999. Climate Change - The Potential for Surprises. *Journal of the Federation of American Scientists* 52, Number 4. Available at <www.fas.org/faspir/V52N4.htm

Philander, S. George, (2000) Is the Temperature Rising? : the Uncertain Science of Global Warming. Princeton, NJ: Princeton University Press

Pinheiro, F. P. and Chuit, R., 1998. Emergence of dengue hemorrhagic fever in the Americas. *Infections in Medicine* **15**(4):244–251.

Pinstrup-Andersen, P., R. Pandya-Lorch, and M.W. Rosegrant, 1999. *World Food Prospects: Critical Issues for the Twenty-First Century*. Washington, DC: International Food Policy Research Institute.

Porter, R., ed., 1996. *The Cambridge Illustrated History of Medicine*. New York: Cambridge University Press.

Reilly, J., et al., 1996. Agriculture in a Changing Climate: Impacts and Adaptations. In: IPCC. 1996c. *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change*. Cambridge, UK: Cambridge University Press, pp. 427–67.

Reiter, Paul, 1996. Global Warming and Mosquito-borne disease in USA. *Lancet* **34**8: 622.

Reiter, Paul, 2000. From Shakespeare to Defoe: Malaria in England in the Little Ice Age. *Emerging Infectious Diseases* **6**: 1–11.

Roberts, D. R. et al., 1997. DDT, Global Strategies, and a Malaria Control Crisis in South America. *Emerging Infectious Diseases* **3**: 295-301.

Roberts, D.R., S. Manguin and J. Mouchet, 2000. DDT House Spraying and Re-emerging Malaria. *Lancet* **356**: 330–332.

Rogers, David J. and Sarah E. Randolph, 2000. The Global Spread of Malaria in a Future, Warmer. *Science* **289**: 1763-1766.

Rosenberg, H. M., et al., 1996. Births and Deaths: United States, 1995. *Monthly Vital Statistics Report* **45** (3, supp. 2): 31.

Rosenzweig, Cynthia, and Martin L. Parry, 1994. Potential Impacts of Climate Change on World Food Supply. *Nature* **367**: 133–138.

Singer, S. Fred, 1997. Hot Talk, Cold Science : Global Warning's Unfinished Debate. Oakland, CA: Independent Institute.

Sleigh, A. C., Xi-Li Liu, S. Jackson, Peng Li, and Le-Yuan Shang, 1998. Resurgence of Vivax Malaria in Henan Province, China. *Bulletin of the World Health Organization* 76.

Smillie, W. G., 1952. The Period of Great Epidemics in the United States (1800–1875). In: R.H. Top, ed. *The History of American Epidemiology*. St. Louis, MO: C. V. Mosby, pp. 52–73.

Tans, P. P. and J. W. C. White, 1998. The Global Carbon Cycle: In Balance, With a Little Help From the Plants. *Science* **281**: 183–184.

Taubes, G., 1997. Global Warming: Apocalypse Not. *Science* **278**: 1004–1006.

Tian, H. et al., 1998. Effect of Interannual Climate Variability on Carbon Storage in Amazonian Ecosystems. *Nature* **396**: 664–667.

(UNFCCC) UN Framework Convention on Climate Change, 1992. *UN Framework Convention on Climate Change*. <www.unfccc.de>.

Warrick, R. A., et al., 1996. Changes in Sea Level. In: IPCC. 1996b. *Climate Change 1995: the Science of Climate Change*. Cambridge, UK: Cambridge University Press, pp.359–405.

Wigley, T. M. L. et al., 1996. Economic and Environmental Choices in the Stabilization of Atmospheric CO2 Concentrations. *Nature* **379**: 240-243.

Wigley, T. M. L., 1997. Implications of Recent CO_2 Emission-Limitation Proposals for Stabilization of Atmospheric Concentrations. *Nature* **390**: 267-270.

Wigley, T. M. L., 1998. The Kyoto Protocol: CO_2, CH_4 and Climate Implications. *Geophysical Research Letters* **25**: 2285-2288.

Wilcove, D. S., et al., 1998. Quantifying Threats to Imperiled Species in the United States. *BioScience* **48**: 607–615.

Wittwer, Sylvan H., 1995. Food, Climate and Carbon Dioxide: The Global Environment and World Food Production. Boca Raton, LA: Lewis Publishers, pp. 56–57.

World Bank, 1999. *World Development Indicators*. CD-ROM. Washington, DC: World Bank .

World Climate Report, 2001. Satellite 'Warming' Vanishes. Vol **6**, no. 9.

(WHO) World Health Organization, 1997. *Health and Environment in Sustainable Development*. Fact Sheet No.170. Geneva: WHO.

(WHO) World Health Organization, 1999. *The World Health Report 1999*. Geneva: WHO.

(WHO) World Health Organization, 2000. *The World Health Report 2000*. Geneva: WHO.

(WRI) World Resources Institute, 1998. *World Resources 1998–99 Database*. Washington, DC: WRI.

How Precaution Kills: The demise of DDT and the resurgence of malaria

Roger Bate

Introduction

Many of our preoccupations arise from the modern paradox: while our longevity, health and environment have never been better, we spend more time than ever worrying about all three. Concerns include both long-standing scares, such as alar, saccharine, breast implants, passive smoking, nuclear power, pesticide residues in food, children's vaccines, and more recent scares, such as mobile phone radiation, GM foods and global warming. In some cases, the concern is completely invalid; in others the scare is out of all proportion to the likely threat. For several years, my colleagues and I (at the European Science and Environment Forum www.scienceforum.net) have attempted to expose these falsehoods or exaggerations by writing in newspapers, publishing papers and editing books. We emphasize that while the threat may be real but tiny, the scare generated will at best, divert resources and at worst, actually cause significant mortality in poor countries.

A possible cause of this disastrous consequence is that intellectuals in less developed countries, (LDCs) far from treating western preoccupations as baseless affectations of the very rich, actually adopt these same worries, assuming perhaps, that these are proper concerns for progressive thinkers. For example, it is instructive to compare the analysis of risk issues in France and the francophone African State of Burkina Faso. The medical, environmental, geographical and political problems of Burkina Faso are radically different from those in France, yet in a study of responses to questions of risk, intellectuals in Burkina Faso gave markedly similar answers to students in France. In fact, intellectuals in Burkina Faso had 'borrowed' concerns relevant only to France, and these opinions were reflected in the media (see Craven and Stewart, 1997). Thus, such issues as the hypothetical threat of cancer from overhead power-lines – against a background of a widespread lack of electricity for refrigeration of food and medicines or lighting for schools – are given a public airing, while serious, but perennial problems are ignored.

Why this happens is not properly established but it appears that media coverage in LDCs is generally likely to follow media coverage in powerful trading partners (such as USA), or former colonial powers (such as France or Britain). Many university graduates in developing countries have been educated in the West and have likely acquired a Western world-view. When they return home, these graduates will become opinion-formers in government, education and the media. Another aspect is that international donor agencies frequently promote projects that reflect their priorities back home and not necessarily what is required in the LDCs. Seatbelt campaigns in countries where the only cars are those owned by the aid agencies is a good example (Bate, 2000).

Even where the local media addresses local problems, the solutions proposed will often be driven by western concerns, which may be inappropriate to local conditions. Where they do act differently, local officials often go up against an unwritten consensus, a tacit international agreement about the 'correct' way to deal with an issue, in what is known in the jargon as a 'status marker' of opinion (Boehmer-Christiansen, 2000). Recent examples include: South African President, Thabo Mbeki's original stance on AIDS; Chinese officials' refusal to sanction a UN convention on tobacco; OPEC States' refusal to go along with the climate change consensus. In all three examples, dissidents have felt the opprobrium of the English-speaking media – conservative and liberal alike (Bate, 2000). That's not to say that officials from these countries were correct to do what they did, but it is their diplomatic duty to put their country's interests first.

There are many reasons, such as the expectation of a hostile media response, political pressure, or even personal aggrandizement, why poor country politicians do not always do what is, seemingly, best for their people (Thurow, 2001). There are probably thousands of examples of this, from policy on irrigation and agricultural development to education of women and rights of the child. Analysis is limited in the literature (probably because research costs are so high, not so much in discovering anecdotal examples but in following them through into a detailed study). In the environmental field they are rare, and rarely documented properly.

However, a pattern is emerging in the application of the precautionary principle (PP) in developing countries (Mooney and Bate, 1999). This principle, which can be interpreted as saying that: 'where there is a threat of serious harm from a technology, lack of scientific knowledge shall not be used as a reason for postponing cost-effective measures to prevent harm'.

While it may seem reasonable to 'look before you leap', the practical interpretation of the PP in many western country policies, means that only 'looking' is allowed, even though 'leaping' is what has allowed humankind to progress beyond the cave. There are many publications that have addressed this over-precautionary problem in the use of the principle (the best is probably Morris, 2000). My particular concern is how the application of the principle is being exported from the rich nations to the poorest on the planet with fatal consequences. Too often, the precautionary principle is zealously promoted without due thought to the likely consequences (Morris, 2000).

Problems with the precautionary principle (PP)

The PP purports to be a rule for decision-making in uncertainty. In practice, however, it is quite the opposite: it is a means of imposing arbitrary restrictions on the use of new technology, be it products, processes or services.

For example, previous risk management strategies have argued that non-proximate risk should be treated less seriously than proximate risk. But many proponents of the PP argue that remoteness of harm is not an excuse for inaction: the mere *possibility* that use of a particular technology *might* have an adverse consequence is sufficient for PP proponents to try to block or restrict that technology. This significant potential harm argument is susceptible to the counter-argument that preventing the action (technology) *might* also result in harm to human beings (see Rubin, 2000).

Some interpreters of the PP demand that a technology should not be admitted until it has been proved to be harmless. But this is impossible: it demands a level of knowledge that simply cannot be acquired. The great Aaron Wildavsky observed: 'One could well ask whether any technology, including the most benign, would ever have been established if it had been forced to demonstrate that it would do no harm' (Wildavsky, 1995).

The increasing use of the PP in United Nations conventions is also proving problematic. Proponents of the PP suggest that its application must be open, informed and democratic, and include all affected parties. While this sounds nice in principle, it can be argued that the international agreements that have incorporated the PP have themselves not been arrived at democratically (Morris, 2000). Furthermore, poor countries are at a disadvantage because many of them lack the financial and human capital to fully evaluate the consequences of these agreements (Tren and Bate, 2001).

While it is true that general application of the PP may prevent exposure to new risks, it also prevents reduction of exposure to existing risks. New technologies generally provide net benefits: if they did not, there would be little incentive to produce them.

The danger of precaution in the developing world

In recent years the adoption of the PP in developing countries has caused many adverse consequences. Several examples will serve as an illustration of how this counter-intuitive process works in practice.

- Concerns about trihalomethanes (compounds created in water chlorination, which are carcinogenic in rats) in drinking water, contributed to the Peruvian Government's decision to reduce the chlorination of drinking water. This allowed an outbreak of cholera in Peru in 1991, to spread, largely unchecked, killing thousands. It then spread across South America with a million cases. As far as is known, trihalomethane compounds have never killed anyone, despite causing cancer in rats subjected to the maximum tolerable dose – a very different proposition from consuming trace levels in drinking water (Ghersi, 1999).
- Fear of nuclear power. In many poor African states there is no electricity grid (or coverage is very limited); small communities are dispersed over vast areas, and linking these to a grid is prohibitively expensive. Essentially, this limits all

human and economic development to activities not requiring power. Two technologies with potential to power up Africa are nuclear and solar. South African efforts to introduce a new small-scale nuclear technology, the Pebble Bed Modular Reactor, which is far safer than previous reactors and can be controlled and shut down remotely) are being hampered by international rejection of older nuclear technologies (Kemm, 2000).

- At Alang in the Gulf of Combay on India's Arabian Coast, thousands of rusting old ships are run against the beach and broken apart. 40,000 skilled men work in dangerous conditions to convert half the world's disused ships into scraps of steel to be used in Indian manufacturing. Western health, safety and environmental standards would never allow this operation, but Indian entrepreneurs use a readily available natural resource, the beach, as the expense of building a dry dock would make the operation unviable. The ships are recycled into steel used in domestic low-tech industry. But environmentalists, instead of welcoming this approach have pressured governments around the world to stop the practice. The US Navy has stopped sending its ships to Alang. They argue that the practice is dangerous and potentially environmentally harmful. It certainly is dangerous for the workers, but they earn many more times the income from the alternative back-breaking work in the fields and hence make this trade-off. Similarly, there are localized pollution problems, but these affect the people living and working in the region – who are also capable of making that trade-off on their own terms (see Langewiesche, 2000).

My last example of disproportionate concerns making things worse involves the disease, malaria, and the use of the pesticide, dichlorodiphenyltrichloroethane commonly known as DDT (see Tren and Bate, 2001 for the full story).

Malaria

Most people consider malaria to be a tropical disease, and indeed today it is. But this has not always been the case. In the period called the Little Ice Age (over 300 years ago) malaria was common in England, and was commonly referred to as 'ague'.

William Harvey (who discovered the circulation of blood) wrote: 'When insects do swarm extraordinarily and when … agues (especially quartans) appear early as about midsummer, then autumn proves very sickly' (quoted in Reiter, 2000).

The diarist, Samuel Pepys, suffered chronic ague. Oliver Cromwell died of the ague in a cool September 1658.

William Shakespeare wrote about it in eight of his plays. Most notably in *The Tempest* (Act II, Scene II), the slave Caliban curses his master Prospero, and hopes that he will be struck down by the disease: 'All the infections that the sun sucks up/ From bogs, fens, flats, on my master fall and make him/ By inch-meal a disease!'

The disease is caused by a parasitic single-cell protozoa – plasmodium (such as Vivax and Falciparum) carried by the female Anopheles mosquito (such as atroparvus or funestus). Depending on the type of plasmodia, it either causes periodic fevers or in some people, death.

The cure, quinine powder, was used for the first time in 1660 (this is why we know ague was malaria, since the symptoms were the same, as was the cure). Quinine became known as Jesuit's Powder, and helped cure French King Louis XIV's son. Interestingly, Protestants didn't like to use the powder as it was seen as a Catholic cure.

Even though the cure was known and the disease declined in importance, due to efforts to remove the mosquito's habitat through better drainage (often by planting water-loving eucalyptus trees) major epidemics still broke out throughout Europe until the early 1920s. There were even Russian epidemics as far north as Archangel on the Arctic Circle, also in Holland, Britain, and many US States. Malaria was endemic to Southern US States as well as to Italy and Greece.

These countries completely eradicated malaria after the Second World War when widespread vector control (insecticidal spraying to kill the mosquito) was undertaken – especially with DDT.

History of DDT

DDT was first synthesized in the 1870s, but its insecticidal properties were not rediscovered until the Swiss chemist, Paul Müller, was looking for a new agricultural pesticide. Müller won the Nobel Prize in 1948 for this discovery. DDT had been introduced for malaria, typhus and other insecticide-carried disease control by the US Military by 1944. After the end of the Second World War, DDT was used widely around the world for vector (mosquito) control and in agriculture. The successful use of the pesticide led to enormous optimism and the belief that malaria could be eradicated from the entire globe. The reasons for this optimism were not hard to see. DDT was, and is, highly effective in killing the malaria vector and interrupting the transfer of the malaria parasite. It is also cheap and easy to use, which put it within reach of even the poorest countries' health budgets. Shortly after the end of the Second World War there was also a conviction that vector control, and in particular pesticide spraying, was the only way in which the disease could be tackled.

The early successes of DDT were nothing short of spectacular. In Europe and North America, DDT was widely used and within a few years, the disease had been eradicated from both continents. It is thought that in one year alone, the transmission of malaria in Greece came to a halt. One historian even suggested that malaria eradication 'was the most important single fact in the whole of modern Italian history'.

Perhaps the most remarkable success story however, was found in Sri Lanka (then Ceylon). DDT spraying began in 1946 and, as with South Africa, was an instant success with the island's death rate from malaria falling dramatically. Within ten years, DDT use had cut the prevalence of malaria down from around three million cases to 7,300 and had eliminated all malaria deaths. By 1964, the number of malaria cases had been reduced to just 29 and at the time it was assumed that the war against malaria in Sri Lanka had been won.

India also used the pesticide to great effect. When the malaria control programme was started in 1953, annual incidence was around 75 million and about 800,000 people died. Almost the entire country was malarial, except for the mountainous areas, and there were, and still are, six *anopheline* mosquito vectors. By using DDT, India managed to bring the number of cases down from the estimated 75 million in 1951 to around 50,000 in 1961. The achievement of reducing the number of infections to this degree cannot be overstated and the success in India largely remained, due to DDT, whereas in many other countries it was to be short-lived. Officials at the Indian malaria control programme estimate that, if the natural rate of malaria returned, there would be 225 million cases in India every year; that there are 'only' around 2 million cases a year is almost entirely due to vector control using DDT.

Success for some

Complete eradication of malaria was achieved in only ten countries, four of which were in Europe, and the other six in the Americas and the Caribbean. The international strategy of eliminating malaria from the globe was led by WHO and largely funded by the United States Agency for International Development (USAID). USAID contributed $1.2 billion to the programme between 1950 and 1972. The WHO contributed far less, with $20.3 million between 1956 and 1963, of which $17.5 million was contributed by the United States. All other countries combined contributed only $2.8 million.

These efforts were never fully implemented in Africa, even though it bore the greatest burden of disease. Sadly, this is still the case for malaria and many other communicable diseases. It had been hoped that the swift and decisive use of DDT through well planned and funded malaria control programmes throughout the world would achieve success. But while these plans were successful for some countries, as mentioned above, for others the plans were not appropriate. While vector control using DDT certainly is effective, many countries (especially in Africa) had neither the infrastructure nor the human capacity to ensure spraying programmes were carried out systematically and effectively. However, today the infrastructure is better and an eradication programme would be more likely to succeed.

WHO pushed for rapid implementation of DDT spraying to eliminate the pool of parasites in humans before mosquito-resistance to DDT developed. The World

Health Assembly adopted the Global Malaria Eradication Campaign in May 1955. But a variety of failings – complacency, poor-training, poor DDT formulation, poor medical detection of cases, poor entomological data and lack of political will – led to the demise of programme by the mid-1960s

DDT was remarkably successful in almost all the countries in which it was used, however it was never likely to work as a magic bullet. Malaria is a disease that is influenced by a number of factors, such as climate and the migration of people. Developing a malaria control strategy that was solely reliant on vector control, and in particular on the use of one pesticide (DDT), was optimistic at best and foolish at worst. DDT therefore became associated with failure, although the failure was of policy, not of the chemical.

In addition to the failings already listed, rapidly-rising donor fatigue and some limited DDT mosquito resistance, contributed to the demise of DDT. Environmental and health concerns about DDT (many of which have since been shown to be exaggerated) shifted the issue away from science and towards emotionalism.

Green backlash and its impact today

While DDT was being used in malaria control campaigns and also massively in agriculture, concerns were raised about the environmental impacts of the pesticide (when used in agriculture). Perhaps the most well known attack on DDT was made by Rachel Carson in her book, *Silent Spring*, published in 1962. The book popularized the scare associated with DDT and claimed that it would have devastating impacts on bird life, particularly those higher up the food chain. The fears were based on the fact that DDT and its metabolites, DDE and DDD, accumulate in the body fat of animals. Despite the fact that many of the fears surrounding DDT were unfounded and the studies upon which they were based unscientific, DDT was banned by the US Environmental Protection Agency in 1972. The publisher's summary on the back of the 1972 edition of *Silent Spring* says:

> No single book did more to awaken and alarm the world than Rachel Carson's Silent Spring. It makes no difference that some of the fears she expressed ten years ago have proved groundless or that here and there she may have been wrong in detail. Her case still stands, sometimes with different facts to support it.

In reality her case does not stand and as the summary states, is purely alarmist.

In 1972, the EPA administrator, William Ruckelshaus overturned scientific reports and evidence given by numerous expert witnesses, the conclusions of which were firmly against a ban of DDT and argued in favour of its continued use. The US National Academy of Sciences claimed that DDT had saved over 50 million lives from malaria. Whereas, Ruckelshaus argued that the pesticide was '…a warning that man may be exposing himself to a substance that may ultimately have a serious effect on his health'. Ruckelshaus's preoccupations with potentially negative environmental and health impacts (despite all the evidence to the contrary) and

refusal to accept the scientific advice offered, condemned millions to death in malarial countries by denying them access to this life-saving pesticide (Mellanby, 1992). The green movement's attitude to DDT in disease control was (and is) nothing short of callous and couched in a neo-Malthusian idea that global populations are growing out of control and that resources are running out. Malaria is therefore bizarrely seen as a saving grace from impending environmental disaster.

Critically, the EPA failed to emphasize that the dose of DDT used in vector control is tiny compared with the amount used in agriculture. There simply is no danger to the environment or human beings from using DDT in vector control, even if there was from agricultural use (Attaran et al, 2000).

DDT is banned

Most developed countries soon imposed outright bans on the chemical for all uses. Some developing countries also imposed a complete ban on the pesticide for agricultural use and (and some for all uses). For example, South Africa banned it for agricultural use in 1974. Sri Lankan officials had stopped using DDT in 1964 believing the malaria problem was solved, but by 1969 the number of cases had risen from the low of 17 (achieved when DDT was used) to over a half million. Pressure not to use DDT was applied by western donors, supported by arguments of resistance, as these were politically convenient. But recent evidence shows that even where resistance to DDT has emerged the 'excito-repellancy' of DDT causes mosquitoes not to enter buildings which have been sprayed (Grieco and Roberts, 2000). In other words, mosquitoes don't like settling on areas sprayed with DDT. Hence it is unlikely that malaria rates would have increased (significantly) even if resistance was found.

Malaria Recovery

Malaria rates have bounced back as explained above. Some environmentalists (McMichael, 1993) consider that this is due to global warming. But, according to world expert Dr Paul Reiter, head of Vector Control at the US Centers for Disease Control in Puerto Rico:

> Increase has been attributed to population increase, forest clearance, irrigation and other agricultural activities, ecologic change, movement of people, urbanization, deterioration of public health services, resistance to insecticides and anti-malarial drugs, deterioration of vector control operations, and disruptions from war, civil strife, and natural disasters. Claims that malaria resurgence is due to climate change ignore these realities and disregard history (Reiter, 2000).

Economic Costs

Controlling malaria is obviously vital for immediate humanitarian reasons, but the economic burden is also crippling development. Professor Jeffrey Sachs at the Harvard University Center for International Development, has analyzed the effects

of malaria on 27 African economies between 1965 and 1990.The study found that the disease cut 1 percentage point a year from the annual growth rates of those economies. If malaria had been eliminated in 1965, Africa's annual gross domestic product would be $400 billion now, rather than $300 billion, the study estimated (Gallup and Sachs, 2001). The models did more than just assess the costs of treatment and losses associated with death. They also estimated the losses from tourists and foreign investors avoiding malaria-prone countries, the damage done by large numbers of sick children missing school and the increase in population and impoverishment that ensues when parents decide to have extra children because they know some will die. Sachs' study confirms research done by Richard Tren of the NGO, Africa Fighting Malaria, which shows the cost to Southern Africa is several billion dollars a year, and this figure was far higher in the past (Tren, 1999).

It is important to note that countries that have continued to use DDT have suffered a lower death rate and lower economic loss than those which have tried to manage without. For example, Ecuador actually increased its use of DDT after 1993 and, during the next six years, saw a 60% decline in new malaria cases. By contrast, Bolivia, Paraguay and Peru, which stopped spraying DDT altogether in 1993, saw new cases rise by 90% over the same period (Mooney, 1999).

Indeed, DDT has quietly been used in developing countries, such as South Africa, Botswana, Ecuador, Indonesia and India for the past three decades, almost without comment. In 1997, however, the United Nations Environment Programme (UNEP) decided to promote a treaty – a framework convention – that would ban 12 persistent organic pollutants (POPs), including DDT.

Rise of conventions – the international community has its way

A UN Framework Convention sets the ground rules and tone of the whole treaty process. It usually establishes conditions that are easy to agree among the parties. In the POPs treaty process (as in all UNEP treaties), the developed world, mainly European and American interests, promote the agenda and draft text. Since these countries do not produce any of the 12 chemicals to be targeted, it was simple for them to promote a total ban under the precautionary principle. If successful, this would allow green groups and politicians to claim an important victory, enabling them to raise revenue and attract voters, respectively. Western industry did not fight to retain any of the chemicals, although it did object to the prohibitionist language originally used in treaty drafts to ban the 12 substances.

The reason the language is not completely prohibitionist is because of three factors: Western industry concern that once the initial 12 chemicals are banned, the green pressure groups and the treaty secretariat will target other chemicals in future protocols, which are produced and used in the west, hence costing them future revenue; officials from developing countries that do produce/use some of the twelve chemicals listed and hence argued for exceptions for certain uses of those chemicals;

pressure from two or three pro-DDT anti-malaria groups who are concerned about the fate of DDT.

The Status of the Convention

In May 2001 in Stockholm, 91 countries signed the United Nations Persistent Organic Pollutants Convention to ban twelve organic chemicals over the next decade. Most of the chemicals will be phased out relatively quickly, but one, the pesticide DDT, has been reprieved for use in controlling malaria for the foreseeable future. Malthusian environmentalists may be privately relieved to know that the reprieve is not really working because even though DDT use is accepted, both under the Treaty and by the World Health Organization, it is becoming harder to procure. It seems that simply being listed under the Treaty is discouraging production and use in malarial countries. Mistaken concerns about DDT are depriving Africans of a safer and longer life.

DDT was probably harmful to wildlife when used in massive doses on cotton farms in the 1950s in America (although not as harmful as Carson and her followers claimed), but it has never been proved to harm humans, except those who tried to commit suicide with it. Any harm to wildlife in America and Europe has been reversed in any event. Furthermore, malaria control only requires that the insides of houses be sprayed – used properly there is very little chance of DDT being released into the environment. Yet myths persist about the harm it causes – many Zambians think it causes male impotence, most westerners think it causes cancer, and nearly everyone forgets that only in massive doses can DDT cause any environmental problems.

Why countries are not acting in their own interest

In summary, there are several reasons why developing countries are not doing the best they can to fight malaria, and all are interrelated. First, western green pressure groups have maintained a PP campaign for thirty years against DDT. Second, aid agencies, now staffed by many environmentalists, have not approved funds in recent years for procurement of DDT based upon PP arguments. Some, such as USAID, have even pressured countries (notably Bolivia) not to use it (Attaran, 2000). Third, governments of the developed world, and increasingly of poor countries, stopped producing DDT, so that only India and China currently produce it in any quantities (Tren and Bate 2001). Fourth, countries, such as Botswana, switched to other pesticides in 1998 when they could not procure any DDT from dwindling world markets (even though this meant buying less of a more expensive alternative. Fifth, the elites in even the poorest countries, such as Mozambique, think it almost unseemly to use a pesticide that has been banned in the North and is due for elimination under the POPs Treaty (Bate, 2002). Last, most people cannot believe

that DDT is still the best pesticide to control malaria vectors, even though it was developed nearly 60 years ago.

Only countries with enough political clout and sense are still using DDT, notably South Africa and India. Even South Africa stopped using DDT in 1996 under pressure to join the world's green community and switched to using the next best alternative – the synthetic pyrethroids (three-times the price and effective over a shorter time span). South Africa decided to resume DDT spraying in 2000 after malaria cases jumped by 1000% due to mosquito resistance while using synthetic pyrethroids.

The only real hope comes from some companies operating in countries that allow DDT to be used. The malaria control programme run by metals company, Billiton, in Richard's Bay, South Africa, and by various other mine companies in Zambia, are examples of the continuing efficacy of DDT. In all places where DDT is being used malaria rates are falling back to levels not seen for over a decade. It is possible that the current supplies of DDT will run out, forcing these excellent operations to switch to the more expensive and less effective alternatives. This will mean that fewer lives may be protected in the future.

While the delegates of the countries who signed the POPs Treaty think they have been magnanimous in exempting DDT from an immediate ban, they have unwittingly consigned many children to death in Africa.

Conclusion

The rise of the use of the precautionary principle is stifling development in Europe and to a lesser, but increasing, extent in America (Morris, 2000). What is clear is that in rich countries the precautionary principle will cost money and, because of its inflexible application, is unlikely to give benefit. On the other hand, inappropriate application of the precautionary principle in poorer countries is most likely to be harmful, sometimes catastrophic.

Concerns about chlorination and the push for a DDT ban are merely the most obvious examples of this phenomenon. In this author's opinion, the PP should rarely be used to make decisions, and never by western advisors to LDCs. However, if the PP is to be adopted more broadly, its interpretation must genuinely be made by those worst affected by its implementation – with full cost–benefit/risk–risk trade-offs acknowledged. However, this is easier said than done. The initial reason for using the PP was to enable decisions to be made when there was considerable uncertainty about the impact of a technology. But it is essential to be rational, to use the best science available and to balance all possible outcomes.

References

Attaran, A., Roberts, D., Curtis. C, Kilama W. (2000) 'Balancing Risks on the Backs of the Poor' *Nature Medicine*. **6**, 7:729–731.

Bate, R. (Ed.) (1997) *What Risk? Science, Politics and Public Health* Butterworth-Heinemann, Oxford.

Bate, R. (2000) *Life's Adventure: Virtual Risk in a Real World* Butterworth-Heinemann, Oxford.

Bate, R. (2002) 'DDT Saves Lives' 14 February www.Techcentralstation.com

Boehmer-Christiansen, S. (2000) *Energy and Environment* **3**,12.

Ghersi, E. and Ñaupari, H. (1999) 'Dirty Water: Cholera in Peru' In: Mooney, L. and Bate, R. (Eds.) (1999) *Environmental Health: Third World Problems, First World Preoccupations*. Butterworth-Heinemann.

Gallup, J.L. & Sachs, J.D (2001) 'The Economic Burden of Malaria' *The American Journal of Tropical Medicine and Hygiene*, **64**, 1,2: 85–96.

Grieco, J.P, Achee N., Andre R. and Roberts, D.R. (2000) A comparison study of house entering and exiting behavior of *Anopheles vestitipennis* (Diptera: Culicidae) using experimental huts sprayed with DDT or deltamethrin in the southern district of Toledo, Belize, C.A. *Journal of Vector Ecology* 25(June):62.

Kemm. K (2000) *A New Era for Nuclear: The Development of the Pebble Bed Modular Reactor* European Science and Environment Forum (ESEF) Cambridge. (www.scienceforum.net).

Langewiesche, W. (2000) 'The Shipbreakers', *Atlantic Monthly*, August.

McMichael, A.J. (1993) Planetary Overload: Global Environmental Change and the Health of the Human Species. Cambridge, Cambridge University Press.

Mellanby, K. (1992) *The DDT Story* Farnham, Surrey, England, The British Crop Protection Council.

Mooney, L. and Bate, R. (Eds.) (1999) *Environmental Health: Third World Problems, First World Preoccupations*. Oxford: Butterworth-Heinemann.

Mooney, L, (1999). Wall Street Journal 'A DDT Ban Would be Deadly' 2 September.

Morris, J (Ed.) (2001). *Rethinking Risk and the Precautionary Principle*. Oxford: Butterworth Heinemann

Reiter, P. (2000) *From Shakespeare to Defoe: Malaria in England in the Little Ice Age* Centers for Disease Control and Prevention, San Juan, Puerto Rico.

Rubin, C. T. (2000) 'Asteroid collisions and precautionary thinking' In: Morris (2000) *Rethinking Risk and the Precautionary Principle*. Oxford: Butterworth-Heinemann

Thurow, R. (2001) Wall Street Journal 'Choice of Evils: As a Tropical Scourge Makes a Comeback, So, Too, Does DDT' 26th July.

Tren, R. (1999) 'Economic Costs of Malaria in South Africa: Malaria Control and the DDT Issue' www.iea.org.uk

Tren, R. and Bate, R. (2001) *Malaria and the DDT Story*, Institute of Economic Affairs, London.

Wildavsky, A. (1995) *But is it True? A Citizen's Guide to Environmental Health and Safety Issues* Harvard University Press, Cambridge, Massachusetts and London.

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- The public are quite capable of making decisions that involve complex trade-offs if only we would let them; indeed, not letting them causes enormous problems as government bodies do not have the dispersed knowledge to do this, and are subject to interest group pressure.
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