Gateway to The Global Garden:

Beta/Gamma Science for Dealing with Ecological Rationality

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FOREWORD

The eighth annual Hopper Lecture in International Development was presented in 2000 by Professor Niels Röling of Wageningen University in The Netherlands, a long-standing European university partner of the University of Guelph. Professor Röling is probably the world's most cited author on rural knowledge and information systems and the facilitation of natural resource management. He has studied and worked in many countries and has been a consultant and advisor to The Netherlands government and a number of other governments, NGO's and development agencies around the world. He is a member of the Board of Governors of ISNAR (the International Service for National Agricultural Research) and is in great demand as a contributor to conferences, books, consulting groups and, just as important, graduate student research. At present he holds a chair in Agricultural Knowledge Systems for Developing Countries at Wageningen University.

As always, we acknowledge the generosity of the Hopper Lecture endowment provided to the University of Guelph by the International Development Research Centre. Each year we offer the lecture in cooperation with another Canadian university; this year it was the University of Saskatchewan.

I also want to recognize the helpful contribution of the Hopper Lecture Committee — Professors Isobel Heathcote, Tom Michaels, David Knight, Nora Cebotarev, Lila Engberg, Dr. Ricardo Ramirez, and especially Isobel Lander, whose services are essential to the continuing success of this lecture series.

This lecture, like its predecessors, is also accessible on the Centre for International Programs website (www.uoguelph.ca/cip).

J.C.M. Shute, Director
Centre for International Programs
University of Guelph

Gateway to The Global Garden[1]

You cannot opt out of science.
- James Lovelock

We cannot use the same methods that got us into the problem to get us out of it.
- Albert Einstein

Overview

1. *The eco-challenge represents a change of context for the human project.*

Our rapidly deteriorating ecosystem due to the impact of human activity represents an unprecedented change – and challenge – for our society. In the past, we have been preoccupied with controlling nature through science-based technology, and with using economic models to optimize outcomes under conditions of scarcity. To these tasks, we now add the eco-challenge: the need to deal with human activities that, collectively, threaten the conditions for life.

2. *Dealing with the eco-challenge is a collective human responsibility.*

No invisible hand, god, or other miraculous force is going to get us out of our predicament. We have to learn our way out.

3. *A change in context calls for a change in paradigm and for knowledge-based action.*

Science and economics are not enough to deal with the eco-challenge. Science-based monitoring of the deteriorating ecosystem is no guarantee that human activities will change – just as epidemiological proof of the link between smoking and lung cancer may have some effect on, but hasn't completely eradicated, smoking behaviour. We need a widely shared paradigm to deal with the new context.

4. *A promising starting point toward an appropriate and unifying paradigm is cognition, the process of knowing.*

Biologists have proposed that cognition, the process of knowing, can be identified with the process of life itself. All living organisms are capable of

[1] I gratefully acknowledge the helpful suggestions of Rudd Dilts, Rhodora Gonzalez, Janice Jiggins, Marleen Maarleveld, Ricardo Ramirez and Jim Shute.

cognitive action. That is, they can assess experience according to some emotion and take action accordingly. A similar mechanism underlies evolution. An analysis of cognitive process leads to a more appropriate definition of rationality than that suggested by rational choice theory. This new definition deals with the cognitive *system,* i.e., with the duality between a cognitive agent and its domain of existence. Rational action aims to maintain the structural coupling between agent and domain. According to philosophers of social science, the biological model of cognition also forms the basis for social science, especially in the proposed search for explanations of collective behaviour. The axioms of economics address the elements of the cognitive system but make unacceptable assumptions about it. In all, cognition promises to provide a powerful, unifying paradigm.

5. *A cognition-based perspective has significant implications for collective human action.*

This lecture addresses some of these implications by

- presenting a typology for exploring the paradigm change from techno-centric thinking to (collective) cognition;
- exploring economics, currently the most widely accepted theoretical basis for thinking about collective human behaviour and for the design of society;
- providing an example from agricultural science that illustrates what happens if one ignores cognitive systems and continues to operate on lower system levels;
- introducing *beta/gamma* sciences as an appropriate focus for analyzing the cognitive system, i.e., the cognitive agent in its domain of existence;
- briefly discussing Multi-Agent Systems (MAS) as a form of modelling that is based on interacting cognitive agents in a domain; and
- discussing the pathology of collective cognitive systems.

6. *The future is a human artefact.*

The perspective presented above draws together a number of implications that could be the basis for human resilience with respect to the eco-challenge. The Earth must be tended as a Global Garden.

7. *An agenda for agricultural research*

The Hopper Lecture ends by addressing the implications for research of land use in the broad sense of the word. Cognition as the process of life leads to a new concept of 'life science'.

Introduction

The IDRC-endowed Hopper Lecture provides a unique opportunity for shared learning and adventure. I am very grateful for having been invited to give the Eighth Annual Hopper Lecture. This invitation challenged me to advance an ongoing project of my wife Janice Jiggins and mine to a point where it could be presented to a sophisticated university audience. At least, that was the intention. As it is, the text below is still a work-in-progress, a bit unsharp and blurred at the edges. Alas, that is how it is.

I would like to thank the Hopper Lecture Committee for its confidence and I am pleased that the faculty and student audiences at both the University of Guelph and the University of Saskatchewan raised many questions after the lectures. These discussions were very useful for my further work on the project. In all, the Hopper Lecture was an unforgettable experience. I am grateful to Dr James Shute, Director of the Centre for International Programs at the University of Guelph, his staff, Dr Asit Sarkar, Director of University of Saskatchewan International and his staff for their organization of the event and for their warm hospitality.

The eco-challenge

The "eco-challenge" was coined by Jane Lubchenco (1998). As President of the American Association for the Advancement of Science, she was confronted with the possibility that the end of the Cold War meant science had run out of things to do and the funding to do them with. After all, society's willingness to pay for scientific research might be at stake once its main perceived purpose – to combat military aggression against the United States – was removed. However, the mounting evidence of the rapid decline of the Earth's ecosystems convinced Lubchenco that we are entering the age of the environment and that the ensuing eco-challenge will provide a new social contract for science. This lecture explores the role of science and social science, and especially of their inter-disciplinary encounter that we now call *beta/gamma* science, in dealing with the anthropogenic eco-challenge.

It is not the place here to dwell at length on the ecological predicament that confronts us. Suffice it to refer to *World Resources 2000-2001: People and Ecosystems, the Fraying Web of Life*, a report on world ecosystems released jointly by the United Nations Development Program (UNDP), the United Nations Environment Program (UNEP), The World Bank and World Resources Institute in September 2000. One hundred and seventy-five scientists contributed to the report that took two years to produce.

The report reveals a widespread decline in the world's ecosystems due to increasing resource demands. It warns that a continued decline could be

devastating for human development and the welfare of species. The report examines coastal, forest, grass land, freshwater and agricultural ecosystems, and analyzes their health based on their ability to produce the goods and ecological services that the world currently relies on. These goods and services include access to water, food, clean air, productive resources, and energy, as well as health, genetic integrity, effective carbon recycling, protection against cosmic rays, climate stability, bio-diversity, and the provision of recreation and tourism opportunities. Most ecosystems are described as being in fair but declining condition. This conclusion is underpinned by statistics such as the following:

- Half the world's wetlands were lost during the last century;
- Logging and conversion have shrunk the world's forests by as much as half. Nine percent of the world's tree species are at risk of extinction; tropical deforestation may exceed 130,000 km^2/annum;
- Fishing fleets are 40 percent larger than the oceans can sustain. Nearly 70 percent of the world's major marine fish stocks are over-fished or are being fished at their biological limit;
- Twenty percent of the world's fresh water fish are extinct, threatened or endangered;
- Soil degradation has affected two-thirds of the world's agricultural lands in the last 50 years;
- Since 1980, the global economy has tripled in size and the population has grown by 30 percent to six billion people.

In short, the ecological basis for human society is rapidly deteriorating because of human activity. Consequently, safeguarding the continued provision of ecological services will feature increasingly prominently on the local, national and international political agendas. In fact, I assume that sustaining the ecological basis for human life will become the highest priority human project in the foreseeable future.

The 'Global Garden' in the title of this lecture reflects my conviction that the Earth must be looked upon as a garden tended by human collective action. The metaphor of the garden underscores the fact that no ecosystem, be it a wetland, forest, mountain range, ocean, or watershed, can continue to exist or be regenerated unless people collectively and deliberately create and sustain the conditions for its existence and regeneration. The world's ecosystems require increasing interactive design and management. Even more, they require that we actively enhance ecological services, for example by using roofs and walls of buildings for carbon sequestration and oxygen production by green plants. In other words, our task is not only to conserve and regenerate, but also to actively design and construct.

Knowledge for dealing with the eco-challenge

Against this background, a number of observations can be made.

- *Humans have become a major force of nature* (Lubchenco, 1998). The eco-challenge is driven by human activity. Meeting this challenge is a reflexive exercise that requires dealing with human behaviour. Hence, people can be considered a 'reflexive major force of nature';
- *The current human project is largely driven by economic concerns.* We measure the effectiveness of our politicians against economic criteria such as employment, incomes, and inflation. The information we get from the media about the state of the world largely reports on economic indicators. Ecological issues may provide worrisome noise, but they are not part of current political and governance systems. For example, a recent unexpected financial windfall for the Dutch government of several billion dollars did not lead to increased expenditure on reducing carbon dioxide emissions, although The Netherlands is very far from honouring its Kyoto commitments. There is as yet no political advantage to be gained by focusing on ecological issues.
- *Societal communication and the collective agenda are dominated by efforts to make people consume more and increase their use of natural resources and ecological services.*
  For example, people, especially children are exhorted to consume processed foods and drinks which add value for manufacturers but cause an increasing incidence of obesity and are linked to the rapid increases in asthma, allergies and dietary intolerances recorded in industrial societies. The US diet is now seen as a major threat to American public health.
- *We have elaborate and widespread scientific knowledge about the bio-physical world and about causal relationships. And we have elaborate and widespread economic knowledge.*
  The former knowledge has allowed us to develop sophisticated technology to manipulate and control these causal relationships. Our widespread material well-being is based to a large extent on this control. Our economic knowledge and practices for managing the economy have allowed us to optimize human outcomes in situations of scarcity based on the operation of market forces. However, we have not developed widespread reflexive knowledge about ourselves and our collective action that could be the basis for effectively dealing with the eco-challenge.

In other words, we have become a major force of nature, but we lack the intellectual instruments to deal with this force – even though increasingly we need this knowledge in order to survive. Neither scientific nor economic knowledge, alone or combined, can get us out of our ecological predicament.

There is no technical fix, and the market fails when it comes to the eco-challenge. In fact, our predilection to technical solutions and reliance on market forces increasingly seem part of the problem (Beck, 1994; Funtowicz and Ravetz, 1993). This is not to say that technology and economics cannot be part of the solution. Rather, technology and economics can help us move toward a sustainable society only if they exist within a framework of collective action that overrides instrumental and economic rationality.

We have been changing our domain of existence in a direction where it no longer can support human life. The signals to this effect are becoming increasingly loud and clear. Yet our ability to act effectively in this new domain of existence is compromised by the fact that our current theories largely deal with yesteryear's challenges: lack of control over nature (science) and scarcity (economics). We now face a different challenge. The context has changed. And human survival depends on our ability to change our paradigm so as to effectively deal with this change (after Kuhn, 1970). That is the challenge this Hopper Lecture sets itself: the search for a more appropriate widely-shared paradigm that provides the "reflexive major force of nature" with the intellectual tools to pull itself out of the predicament it has created.

The key to these intellectual tools may be cognition. Certainly, as witnessed by the following examples, cognition plays a prominent and recurring role across various disciplines. Biologists have recognised cognition as the basic process of life (Maturana and Varela, 1992). This biological perspective allows a sharp definition of ecological rationality. All social sciences, including economics, base their explanation of human action on the operation of a cognitive system (Rosenberg, 1995). In computer simulation, Multi Agent Systems (MAS), which are autonomous and cognitive, are rapidly replacing static linear models (Gilbert and Troitzsch, 1999). Ecologists increasingly recognize the importance of humans in determining ecosystem outcomes and have identified adaptive management based on social learning – the property of cognitive systems – as the key ingredient of a sustainable society (Holling, 1995). Sustainable natural resource management is increasingly seen as the emergent property of "soft systems" (Checkland, 1981; Röling and Jiggins, 1998) and of overcoming social dilemmas (Ostrom, 1992; Steins, 1999; Maarleveld, 2000 in press). Social learning, soft systems and overcoming social dilemmas all refer to processes by which individual cognitive agents realize their common fate and agree to engage in collective action. Conversely, pathologies resulting from failed development and resource degradation, such as frustration and marginalization, seem to reflect defective (collective) cognitive functioning (Merton, 1957; Van Haaften *et al.*, 1999). Finally, an analysis of religious peak experiences (Maslow, 1964) leads to a description in terms of cognition.

Consequently, a unifying and powerful paradigm emerges for addressing the eco-challenge. This paradigm focuses on the behaviour of perceiving,

intentional and reasoning beings engaged in collective action. It identifies (collective) cognitive agents as a key ingredient (indeed, perhaps *the* key ingredient) in sustainable society. Widespread understanding of (collective) cognition seems to be a likely condition for managing change and is therefore the gateway to the global garden.

The Santiago theory of cognition

Though non-living, the cybernetic system or thermostat clearly has a rudimentary cognitive structure and is a useful analogy for a discussion of human cognition (Figure 1).

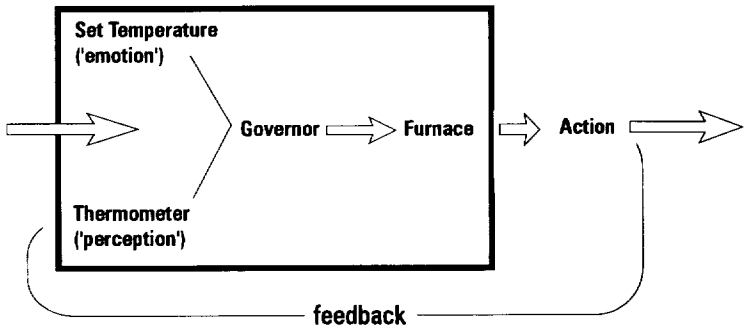

Figure 1: A Rudimentary Cognitive Agent: The Thermostat

(after Von Bertalanffy, 1968)

The thermometer *perceives* what is happening in its *domain of existence*; the set temperature represents *emotion (what is desired)*; and the furnace allows *action* that affects the domain and is again perceived by the thermometer (*feedback*). However, unlike even the simplest cellular organism, the thermostat cannot adapt or learn. There is limited dynamic interplay with the domain of existence. If a fire broke out next to the thermostat, the mechanism would stop working because the temperature would be warm enough.

Typically, neo-classical economics operates at the level of the thermostat with its assumption of a given utility function or preferences (emotion), perfect information (perception) and rational choice (action). This economic thermostat is also blind and dumb, in the sense that destruction of the human habitat counts as desirable economic growth, e.g., driving an automobile contributes more to desirable growth of GNP than riding a bicycle.

Models of higher system levels, cells and more complex living systems contain the elements of the simple thermostat, but go considerably further. We

capture these higher levels with the cognitive system according to the Santiago theory of cognition. This theory, developed by two Chilean biologists, is summarized by Capra (1996; 257):

> In the emerging theory of living systems, mind is not a thing, but a process. It is cognition, the process of knowing, and it is identified with the process of life itself. This is the essence of the Santiago theory of cognition, proposed by Humberto Maturana and Francisco Varela (1992).

Their starting point was the question: how do organisms perceive? Take a frog looking at a fly. The image of the fly cannot be projected on the central nervous system of the frog. In fact, the physical processes that govern the image of the fly (light waves) are totally different from the neurological processes that determine the image created in the central nervous system of the frog. One could say that the central nervous system is informationally closed. There is no way that the fly can be "objectively" projected. But the presence of a fly can trigger change in the central nervous system of the frog. The frog 'does not bring forth *the* fly, but *a* fly'. The active construction of reality is not a human prerogative but a quality of all living organisms.

But, say Maturana and Varela, the frog does not bring forth *any* fly (as pure relativists would have us believe). It brings forth a fly the frog can catch and eat. Organisms and their environment are *structurally coupled.* They maintain this coupling through mutual perturbation. The process by which organisms bring forth *a* world allows them to maintain structural coupling with their environment. This leads Maturana and Varela to their startling and powerful definition of *knowledge as effective action in the domain of existence.*

This definition is startling, not only because so many people think of knowledge as the prerogative of *Homo sapiens*, but also because we are taught to believe that as scientists we are building a store of ever expanding objective knowledge. Maturana and Varela put a new twist on this belief when they suggest that a store of knowledge developed in an old context can become a downright barrier to effective action in a changing context or a new domain. We indeed have developed an enormous body of knowledge. But we appear to have very little knowledge, in the sense of effective action in our new domain of existence – a domain marked by our destruction of the conditions for life.

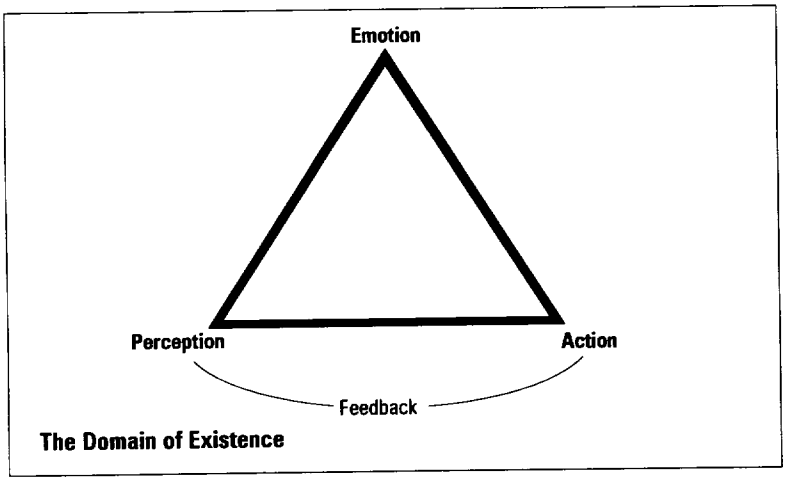

Figure 2: The Cognitive System

(After Maturana and Varela, 1992; Capra, 1996)

According to Maturana and Varela, cognition is the very process of life. Mind is immanent in matter at all levels of life. All organisms are capable of cognitive action, that is, of assessing experience according to some emotion and taking action accordingly. The cognitive system, then, is a co-evolving *duality* of the perceiving organism and its environment: "The new concept of cognition, according to the Santiago theory, is much broader than that of thinking. It involves perception, emotion, and action – the entire process of life" (Capra, 1996; 170). This concept is illustrated in Figure 2.

We observe that the system includes (1) an organism or *agent* that can perceive the environment and take action in it; and (2) the *domain of existence* with which the agent is structurally coupled. We could further distinguish (3) an *ecosystem*, i.e., a space in which multiple agents interact and mutually determine each other's domain of existence.

It is important to note here that Maturana in particular does not identify 'emotion' with 'intentionality'. Nor does he accept that 'intentionality' implies some *a priori* setting of an objective to be attained, that motivates action (as, for example, Searle (1984) would argue in his discussion of consciousness and the perception of freely willed action). On the contrary, the biological basis of cognitive system implies that the triggered response of a perceiving organism's cognitive processes to its environment is necessarily something that occurs 'in the moment'. Learning, that is, occurs in the continuous present and is necessarily adaptive (Jiggins *et al.*, 2000)[2].

[2] I am grateful to Dr. Ray Ison of the Open University, Milton Keynes, UK, for pointing this out.

Ecological rationality

The *ecological* rationality implied by the Santiago theory of cognition differs greatly from the economic rationality implied by rational choice theory. The ultimate rationality of the cognitive agent is to maintain structural coupling with its domain of existence. This suggests that the agent has the capacity to take effective action in its domain by reducing discrepancy between perception, emotion and action, and by being perturbed by, or by perturbing the domain of existence. Taking effective action therefore requires the following capacities:

- *Control:* act to make outcomes satisfy emotion-based purpose;
- *Adapt:* adapt emotion-based purpose to the opportunities (perceived to be) offered by the environment, or to the outcomes that can be elicited (feedback);
- *Learn:* develop perception to fit the opportunities or threats in the environment and adapt action and purposeful behaviour to changed perception;
- *Evolve or innovate:* adapt the ability to take effective action to the perceived and/or experienced threats and opportunities in the domain of existence;
- *Mutate or reflexively manage the cognitive system itself:* when structural coupling cannot be achieved through the above four capacities, deliberately manage the configuration of the elements of the cognitive system, for example by changing restrictive insights or by making the context visible.

Rationality is the effective pursuit of structural coupling. This implies, first, that the three elements – perception, emotion and action – tend towards (cognitive) consistency, a term coined by Leon Festinger (1957). The need for consistency provides 'coherence criteria' for rationality. But it also implies that the consistency achieved can be broken apart by change of the domain. The quality of the structural coupling of the cognitive agent and its domain, or rather between the agent's decision-making and the structure of its environment, provide 'correspondence criteria' for rationality (Gigerenzer *et al.*, 1999; 18). In fact, Gigerenzer *et al.* (1999; 5) describe ecological rationality as "rationality that is defined by its fit with reality". Such rationality requires a remarkable mix of consolidation and self-renewal.

The concept of rationality suggested by the Santiago theory not only seems much richer than the simple goal-seeking rational choice theory used by economics, it also seems a sounder guide for people as a major force of nature. It goes beyond the selfish optimization of outcomes and the strategic rationality of players in the market place who seek to win in competition (Platteau, 1996; 1998). Ecological rationality seeks to create structural coupling and to bring

forth a world that allows structural coupling to be maintained. It is capable of adapting, if that is what is required. In other words, ecological rationality overrides instrumental and competitive or strategic rationality: it is simply more comprehensive and superior.

This paper is based on the premise that all organisms, including humans, are 'wired' to be ecologically rational. But to realize the potential inherent within this and to remain structurally coupled, we must bring forth an appropriate world. Given that collectively people have become a destructive major force of nature, the world they bring forth must allow them to deal *reflexively* with collective cognition.

Cognition as the basis for social science

Scientists typically consider social science an oxymoron, a contradiction in terms. Social science does not deal with causal factors. It cannot predict. It is interpretation and verbiage that does not lead to change, let alone the improvement of the world. Put briefly, social science cannot put a person on the moon. As a social scientist in an agricultural university, I am all too familiar with this thinking. The dilemma is that such a negative perspective can blind people to the possibilities that the social sciences offer: understanding the behaviour of human collective cognitive agents can bring forth an appropriate world to deal with the eco-challenge. Social science, therefore, has *survival* value.

The condemnation of social science is based on the fact that it has a totally different point of departure from natural science, especially the reductionist positivist kind.

For the conventional scientist, reality exists independently of the observer. Through scientific methods and research it is possible to build objective, ever-expanding knowledge about that reality. Applied scientists, then, use that knowledge to develop the best technical means to deal with problems, such as hunger, soil erosion and what not. These goals themselves are not part of the investigation. In all, science seeks to predict natural phenomena based on discovering natural laws governing cause and effect. Such prediction allows for technology to instrumentally manipulate causal relationships. Science has been phenomenally effective in making nature work for us.

Social science is a totally different enterprise. It too tries to predict, or at least explain, human behaviour. But the causal factors involved are invisible moving targets that defy law-making. They include *desires* (emotion, motivation, objectives, attitudes, norms and values), *beliefs* (knowledge, sense-making, inference and interpretation) and *action*. Human action is explained in this way:

> "If any agent, x, wants d, and x believes that a is a means to attain d under the circumstances, then x does a" (Rosenberg, 1995; 31).

The environment fosters within us desires and beliefs that lead us to take certain actions. Unlike other causes, desires and beliefs are also *reasons* that make behaviour intelligible to us (Rosenberg, 1995; 33). Agents are rational to the extent that they undertake the actions that are best justified, given the ends. The social sciences investigate the degree to which people's behaviour reflects the actions of a rational agent. The aim of the social sciences is to interpret beliefs, desires and action in their mutual adjustment and coherence and in their adequate collective correspondence to the demands for effective action in the context. Coherence and correspondence provide the criteria for rationality in which the social sciences are interested[3].

It is easy to recognize in social science the basic elements of the cognitive system described in Figure 2. Social science is basically about cognition, as defined by the biologists. Its very essence is to understand how people (collectively) bring forth a world, and hence it is basically constructivist instead of positivist. The, of necessity, socially constructed nature of reality is also the basis for the effectiveness of social science. Giddens (1984) speaks of "double hermeneutics". Whether people think the sun turns around the earth or vice versa does not affect the behaviour of these celestial bodies, says Giddens. But what people think of other people can strongly affect the behaviour of the latter. People bring forth a world, (i.e., they construct their domain of existence which includes themselves as major determinant). Others, including (social) scientists, can strongly affect that world. In fact, one can say that all science, whether natural or social, is effective, not by the power of its predictions, but by the extent to which it affects the worlds people bring forth and the behaviours based on those worlds (Callon and Law, 1989). In that sense, social science can be very effective indeed by helping bring forth worlds that affect collective behaviour, including the behaviour of people as a major force of nature. This power of social science brings in a moral element: "the dissemination of social science could not only affect action, it should also effect action" (Rosenberg, 1995; 116).

Neo-classical economics is the social science that currently is most influential in informing reflection about collective behaviour. We see ourselves as

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[3] Rosenberg (1995) only emphasizes the coherence criteria. Gigerenzer et al (1999) have made me aware of the importance of correspondence criteria, especially for understanding ecological rationality. They reject the reliance in the social sciences on coherence criteria. I believe that the cognitive agent is doomed to construct 'restrictive insights' that are based on coherence (mutual adaptation of perception, emotion and action) in an effort to create correspondence. Hence both are equally necessary. What is of interest is how new contexts (a new need for correspondence) leads to the need for a paradigm shift (new coherence).

programmed to pursue a set of preferences and to be driven to win in competition (Platteau, 1996). Furthermore, we have information about the world, be it perfect or bounded. And thus we make rational choices when engaging in action. The emergent property of these collective choices is the market. Most people in industrial nations accept or have no alternative to the notion that the independent functioning of market forces leads to the "greatest good for the greatest number", to use the Benthamite expression. Hence neo-liberalism is the main ideology of the day.

The trouble is that the market fails when it comes to dealing with the eco-crisis. In fact, its unhindered working is increasingly recognized as the very cause of it. Economics is currently our only widely shared basis for reflection about collective action, but it is totally unsuitable as the basis for bringing forth an appropriate world in a context marked by the eco-challenge. Consequently, we urgently need to develop another basis for informing collective action. And hence our effort to explore collective cognition.

Some social scientists explain what happens at higher system levels as the emergent property of the activities of individuals (e.g., a beneficial market emerges as a result of selfish individual action). This explanation is called methodological individualism (Rosenberg, 1995). Others, such as anthropologist Mary Douglas (1986), argue that the collective level (institutions or culture) strongly determines the activities of individuals. Structuration theory (Giddens, 1984) which focuses on signification, legitimation and domination as major processes, recognizes the mutual nature of the structural coupling with the social domain of existence: individual action is determined by structure, but structure is created through individual action.

In social dilemma theory, humans are holons with a Janus face (Koestler, 1967). They are sub-assemblies in a larger whole. If they look down, they see that they are autonomous agents and focus on self-assertion. If they look up, they see that they are part of larger wholes and focus on integration. In a social dilemma, the rational individual choice is autonomy, although each agent would be better off if all chose integration. Hence, social dilemmas can be overcome through deliberate agreement and through creating institutions that remove the attractiveness of selfish choices (Ostrom, 1992). When the emergent property of individual activities is self-destructive (e.g., when the collective impact of stealing undermines the fundamental principles of civil society, or when the collective impact of individual economic activity destroys the human habitat), people are capable of creating agreements and institutions at the collective level which override individual selfish behaviour (Hounkonnou, in prep.).

In this connection Uphoff (2000) and Uphoff and Wijayaratna (1998) emphasize the importance of social capital, which they define as an accumulation of various types of social, psychological, cultural, cognitive,

institutional and related assets that increase the amount (or probability) of mutually beneficial co-operative behaviour. They see structural and cognitive phenomena that are conducive for mutually beneficial collective action as specific things that can be identified and invested in. They have analyzed social capital in irrigation schemes, where there is a high degree of mutuality, common identity and benefit to be derived from co-operation, not just for personal, but mutual benefit. For example, everybody benefits when the common resource, water, is used efficiently. Uphoff (2000) convincingly shows that by increasing the social infra-structure[4] in "one of the most deteriorated and disorganised irrigation schemes", the production of rice per unit of irrigation water issued had been increased by about 300 percent. An irrigation scheme is a good metaphor for a world facing the eco-challenge. It too has a high degree of mutuality, common identity and benefit to be derived from co-operation.

Humans need to bring forth a world to deal with themselves as a destructive major force of nature. Hence they reflexively need to bring forth a world that deals with collective cognitive systems, i.e., with social learning, and social capital (networks, organizations and institutions) for sustainably managing eco-systems at the nested ecosystem levels which seem essential for maintaining structural coupling.

I conclude that social science is not an oxymoron but the key science for dealing with the eco-challenge. In this, I differ with Lubchenco (pers. com.) who believes that dealing with the eco-challenge requires natural scientists to tell people 'what is out there'. Of course, making visible the eco-challenge by natural scientists is an essential ingredient in designing a collective cognitive system that effectively pursues ecological rationality, much as epidemiologists are essential for making visible the impact of a bad diet on health. In that sense, "(we) cannot opt out of science". Having taken responsibility for the outcomes of ecosystems, we now have to live by our wits. But that is not enough. Dealing with such information requires change in human (collective) action based on widely shared reflexive understanding of collective cognition.

Finally, ecological rationality overrides instrumental and economic rationality. Happiness is not related to wealth. Ecological rationality requires redesigning our institutions and other forms of collective action that are mainly informed by economics. We need a theory that can inform a more evolutionary and less self-destructive practice. Economics is a special case of collective reflexive cognition. It is vital that we advance the argument.

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[4] 'Social infra-structure' refers to a network of farmer organizations, beginning with small informal groups (10-20 members) headed by a farmer representative (FR) chosen by consensus and serving on an unpaid basis. All FRs for field channels drawing water from a given distributary canal formed a Distributary Canal Organization which had, eventually, formal legal status. FRs also met regularly in larger area councils, and they selected from among themselves trusted FRs to serve on a joint management committee with engineers and other officials.

The change of paradigm

Accepting collective cognition as a basis for thinking about the future requires a paradigm change (i.e., a change in epistemology, ontology and methodology). In his studies on the spruce budworm in the New Brunswick forests, Allan Miller (1983; 1985) has suggested a graph, further developed by Bawden (1997) and slightly adapted by me, which allows us to visualize this change of paradigm (Figure 3).

The first quadrant (I) represents the restrictive insight based on reductionism and positivism. Miller called it the "techno-centric" quadrant. His colleagues operating in it were likely to promote chemical spraying as the best strategy for dealing with the spruce budworm.

The second quadrant (II) is still based on positivism, but has moved on to a holistic perspective. Ecosystem approaches fall into this quadrant. But people as cognitive and intentional beings do not feature in this type of thinking. Of course, some ecologists, such as Holling (1995) and his colleagues, have not made that mistake. They conclude that ecosystems in which humans play dominant roles can be maintained only if those humans engage in adaptive management and in the kind of social learning that allows human institutions to engage in adaptive management (Jiggins and Röling, 2000). But ecologists usually look only at 'natural' systems. Miller observed that colleagues operating on the premises of quadrant II were likely to advocate Integrated Pest Management approaches to combat the spruce budworm.

Quadrant III is less straightforward. It represents a holistic approach coupled to a constructivist epistemology. Thus it gives space to soft system thinking and methodology (Checkland, 1981; Checkland and Scholes, 1990), to social learning in the sense of humans' collective learning to manage themselves, to futures that emerge from human interaction among multiple stakeholders, and to communicative rationality (Habermas, 1984; 1987). In this quadrant one can effectively look at humans as intentional and learning cognitive agents, and at human organizations as collective or inter-subjective cognitive agents. Miller observed that few colleagues based their spruce budworm management on the assumptions of Quadrant III. But collective action negotiated among the multiple stakeholders in the spruce forest is probably what he would have seen. After all, the outbreaks of budworm resulted from humans planting enormous tracts with one species of tree, so the real solution was not a question of dealing with the worm but with human systems.

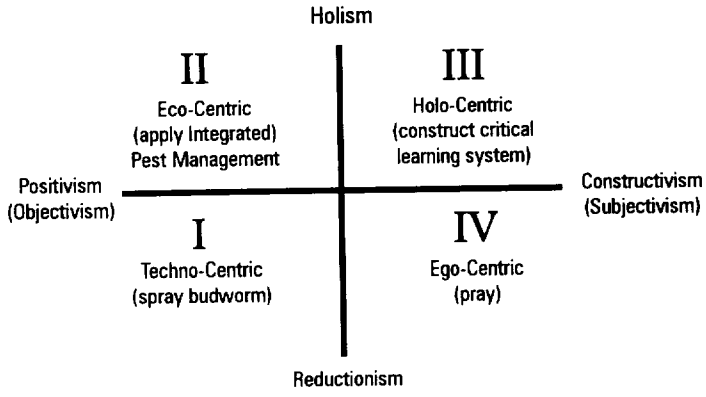

Figure 3: A typology showing the paradigm shift between restrictive insights (the case of the spruce budworm)
(Based on Miller (1983 and 1985) and Bawden (1997))[5]

Quadrant IV is a difficult one. It could represent the condition in which people still subscribe to constructivism but have learned or accepted that ecologically rational collective action is not within the grasp of human beings. Miller typifies the action in this quadrant as 'pray'. But perhaps this quadrant also provides a home for those who consider spirituality as a key ingredient in ecological rationality and as the step beyond soft systems (e.g., Van Eijk, 1999; Auerbach, 1999; Wielinga, pers. com.). In that view, a direct link between explicit discursive consciousness, on the one hand, and deeper layers of implicit knowledge (Broekstra, 1998) and transcendental consciousness, on the other, is necessary if we are to break through the current restrictive insights of science and neo-classical economics.

Maslow (1964), who analyzed religious peak experiences of a large number of people, names the following key aspects reported by most of his respondents:

- The clear perception that the universe is one whole of which one is an integral part;
- Non-judgmental, or comparative, total acceptance of everything;

[5] Prof. Tony Fuller of the University of Guelph has helpfully pointed out that the numbers used for the quadrants not only do not correspond to the scientific convention, but that they also suggest linearity and a necessary point of entry. Futhermore, they suggest that, once you leave one quadrant, that is it. Therefore, it negates the possibility that one can choose to operate in different quadrants, depending upon the problem encountered.

- The sense of being lifted to greater than normal human heights and the ability to see things beyond normal human concerns;
- An experience that justifies life as such, that perceives the world as good, beautiful, and never as bad or undesirable. Existence becomes sufficient in itself.

Maslow summarizes the experience in this way: "The complete human person at certain moments is able to perceive the unity of the cosmos, to fuse with it and rest in it, for the moment totally satisfied in his desire for being at one" (1964; 92). In Japanese Zen Buddhism, such a religious peak experience is called Satori, a transformation of paradigm. This transformation is the goal of those who practice Zen (Suzuki, 1994). It seems that such spirituality is the wellspring of ecological rationality. In this view, ecological rationality is more than a self-serving interest in survival; it is also a spiritual path leading to the experience of our essence.

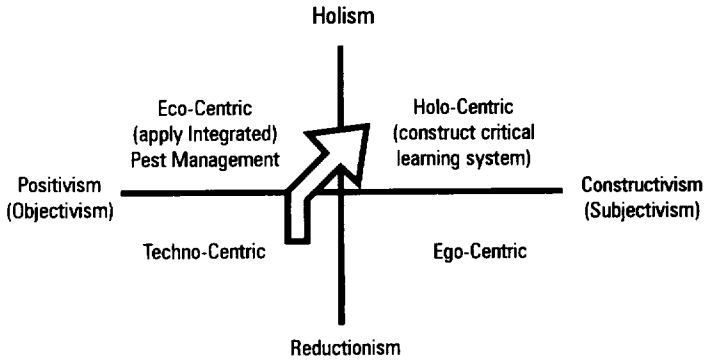

Figure 4: The movement from the future as technical design to the future as human artefact

The Miller/Bawden scheme allows me to make a bold statement. The eco-challenge requires that we move from Quadrant I through Quadrant II to at least Quadrant III and, some would argue, to Quadrant IV. Figure 4 depicts this movement. My experience suggests that those who are still in Quadrants I or II find it impossible to understand Quadrant III, while Quadrant III encompasses the previous two. Hence any university or other institution concerned with training professionals for managing the human use of land, natural resources or ecological services should make the move to Quadrant III a priority. But this is running ahead of my story.

The move represented in Figure 4 reflects movement to a higher system level.

General systems theory (Boulding, 1968) distinguishes seven levels of theoretical discourse: (1) static structures (frameworks); (2) simple dynamic systems (clockworks); (3) self-regulating, cybernetic systems (thermostats; Fig. 1); (4) self-maintaining living structures (cells) and (5, 6 and 7) more complex living and self-organizing adaptive systems. Each higher level presumes the lower one. Adequate theoretical models extend to the fourth level and not much beyond. The level of the clockwork is the level of classical natural science. I assert that the movement from Quadrant I through Quadrant II to Quadrant III represents reflexive moving up system levels from respectively the clockwork and the self-regulating thermostat to self-organizing adaptive reflexive systems.

Restrictive insights: agricultural science

Bawden (2000) has provided us with a tool to consider the reflexive cognitive agent. Praxis is practice informed by theory. It is the practice which emerges from deliberate, interactive and mindful iteration through major anchor points of cognition and decision-making: context, values, theory and action (Figure 5).

One easily recognizes the elements of the cognitive system, except that the elements are now coined in terms of inter-subjective discourse. Consistency-seeking iteration through the elements gradually gels into a configuration which blinds the person or collective to the changes in the environment. This blinding effect includes the perception of context which becomes part of the consistent self-referential configuration. But as Thomas Kuhn (1970) argues, changes in environment, and to a lesser extent in social values, theory and technology, allow people to break through the bondage of self-referentiality. Hence there is a pulse of consolidation (coherence criteria) and self-renewal (correspondence criteria). This pulse is, in my opinion, of key importance for understanding the collective cognitive systems (Eshuis, in prep.).

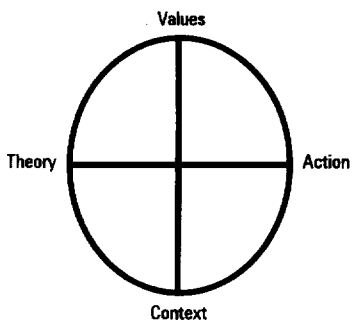

Figure 5: The Elements of Praxis and their Relationships
(Bawden, 2000)

Bawden's notion of praxis is helpful for analyzing restrictive insights and for thinking about how we get out of them.

By way of illustration I will describe a typical agricultural restrictive insight and the way we are getting out of it. Wageningen University's most famous professor, Cees De Wit, defined agriculture with breathtaking and destructive clarity (1974): "Agriculture", he said, "is harnessing the sun's energy through plants for human purposes."

As a result of the work of De Wit's students, Wageningen has become famous/notorious for its crop growth simulation models that focus on a-biotic variables and natural laws. These models integrate the hard agricultural sciences into inter-disciplinary efforts that allow prediction, for example, of global maximally attainable yields, and hence of the human population that the earth can support. This approach has been heuristic in generating a great deal of research and refreshing in toppling established truths. An example is the thesis that it is not lack of water but lack of nutrients that limits bio-mass production in the Sahel.

If we look at De Wit's definition of agriculture in terms of Fig. 5, we can observe the following.

- The *context* is determined by a-biotic factors, and the dynamic forces that govern it are natural laws. Hence the system level is the clockwork or at most the thermostat (Boulding, 1968). The context is assumed to exist irrespectively of the human observer and to be objectively knowable by scientific research (positivism).
- The *theory* concerns harnessing the sun's energy through plants and only addresses the a-biotic factors and natural laws, and not, for example, other cognitive agents in the domain. The action is technical or instrumental.
- This action serves human purposes (*values*). In Wageningen practice, these purposes are assumed and translated into achieving maximum production and, more recently, under the impact of the sustainability debate, maximum resource efficiency. The scientist's purpose is to develop the best technical means to achieve these purposes.
- In its systems orientation, De Wit's perspective overcomes reductionist science and moves to **Quadrant II** (Figure 3). And, through its systems approach, it provides a basis for inter-disciplinarity among the hard sciences.

De Wit's perspective has been and remains very influential. It contains, however, distinct disadvantages and blind spots. Although De Wit was an active socialist, his perspective does not include people. People do not feature in the models, but utility functions have been built in. There is a general recognition

that, once scientists have developed the best technical means, communication specialists like me come in handy to deliver them to ultimate users.

Another problem with De Wit's perspective is that the limited definition of the context does not take into account its ecosystemic nature. Hence, according to De Wit-type models, the earth can support as many people as can be fed by producing the maximally attainable grain equivalent yield of 10 tonnes per ha on the available arable land. This calculation does not take into account the likelihood that such production would probably destroy the complex web of life, and the biosphere as a complex adaptive system on which we depend (Capra, 1996).

Totally ignoring the existence of people in the domain of existence also leads to remarkable distortions. For example, according to this model, West Africa would be able to produce sufficient food for its rapidly rising population by 2040, given its exposure to sunlight, available water and the nature of its soils. However, this expectation does not take into account the intractability of the 'soft side of land' (Röling, 1997). Agriculture is embedded in rights to land, in knowledge and technology and the societal capacity to change them, in the cultural traits of local people, and in the institutions and infrastructure (including markets) of the societies concerned. It has so far apparently not been rational for West African farmers to embark on the kind of science-based agriculture that would be required to reach 10 tonnes per ha, even though they have been exceptionally innovative in coping with change (Mazzucato and Niemeijer, 2000).

Thus, one can see that De Wit's restrictive insight and its domination of the Wageningen intellectual scene seriously handicap the University's intellectual leadership for dealing with the eco-challenge.

Interestingly, this restrictive insight is now slowly being undermined. Scientists who have believed for years that their systems approach could lead to policy based on scientific truth are slowly realizing that policy makers in both industrial and developing countries are not using their models. Their work has had little impact. In the ensuing uncertainty one observes a remarkable receptivity for other ideas, such as the typology illustrated in Figure 3. This does not mean, of course, that the overwhelming thrust of the university has shifted from technical positivist science. The life sciences (narrowly defined as biotechnology) are the latest enthusiasm and are seen as the future basis for the social contract of agricultural science. I agree with Lubchenco (1998) that the eco-challenge seems a much more lucrative mission.

But even when the eco-challenge is accepted as *the* problem, the core of the problem – human collective behaviour itself – is not necessarily recognized. An example is contained in the conclusion of the report *World Resources 2000-2001: People and Eco-system, the Fraying Web of Life*. The advance Internet billing of the report says:

> One of the most important conclusions is that there is a lack of much of the baseline knowledge that is needed to properly determine ecosystem conditions on a global, regional or even local scale ...The dimensions of this information gap are large and growing, rather than shrinking as we would expect in this age of satellite imaging and the Internet. In all, the report provides impetus for the Millennium Ecosystems Assessment, a plan put forward by governments, UN agencies and leading scientific organisations, to allow an on-going monitoring and evaluation of the health of the world's ecosystems.

In other words, recognition of the eco-challenge as a key threat to human survival leads to calls for more scientific research on the state of ecosystems. But this is the same as trying to reduce the incidence of lung cancer by more research into the relationship between smoking and mortality. We now know that we need to focus on smoking itself and on the corporate behaviours that promote it. Some jurisdictions now accept that cigarette manufacturers are liable for the consequences of smoking and label packages of cigarettes with a health warning. We may soon draw similar conclusions with respect to the anthropogenic eco-challenge. For example, a recent overview of the environmental fate and toxicology of organo-phosphate pesticides (Ragnarsdottir, 2000) leaves one with the expectation that pesticide companies will soon be in the same position as cigarette manufacturers are now.

Paradigm shift in economics?

Before concluding the discussion of paradigm shifts, I would like to point out that Figures 3, 4 and 5 largely refer to science and not necessarily to economics. During my life as a faculty member in an agricultural university, I have become convinced that classical economic thinking (assuming selfish and strategic calculation) has a much greater effect than positivism and reductionism on the reflexive understanding of students and faculty. It is also much more difficult to discuss. Students believe in strategic narratives and dismiss as naive the belief that agreement or institutions can override selfishness (Röling and Maarleveld, 1999). Ridley (1995) has also struggled with this issue. I have encountered many economists who hold the positivist notion that the market is a force of nature, much like gravity, which is not amenable to deliberate human decision-making, and who are oblivious of the debate going on in economics itself. Tamborini (1997) points out the folly of such oblivion:

> The knowledge of human knowledge claims a place of its own in economics. Beyond the walls of our discipline, spectacular progress is taking place in the field of empirical research into human knowledge –the so-called cognitive sciences. In the light

> of such advances, the old and classical axiom that nothing scientific can be said beyond the axioms of substantive rationality now looks very much like the protective belt of a degenerating programme.

Simon's formulation of "bounded rationality" (1969) and North's identification of institutions as mediators of information (1990) have led recently to numerous new perspectives on the cognitive basis of economics. In an attack on methodological individualism, Arrow (1994) concluded that "social variables, not attached to particular individuals, are essential for studying the economy or any social system, and that, in particular, knowledge and technical information have an irremovably social component, of increasing importance over time."

In a distinguished lecture on economics in government, Aaron (1994) chastises his discipline for failing to take the formation of preferences seriously ("the recalcitrant refusal of economists to venture beyond a model of human behaviour others see as seriously incomplete"). He also laments the reliance on a model of utility that has no relation to current psychology, and draws attention to the following claims as directly relevant to economics:

- People never know the full consequences of their actions;
- The human brain does not contain a central processing unit, a giant server supervising many workstations. A more useful metaphor is of the brain as a massive parallel processing unit (see also Clark, 1997);
- People have a capacity for self-reference through which they can judge their own lives and relationships;
- Humans derive satisfaction from helping each other;
- People care about others as ends, not only as means;
- People derive enormous satisfaction from interpersonal relationships;
- The satisfaction people take from setting goals and achieving them has erroneously been singled out as the most important;
- The most palpable reality of all our lives is internal conflict.[6]

Aaron argues that each person operates more than one utility function, including self-respect, profit, others' regard and social capital. The trade-offs that are made among them, and the utility function that is determinant at any time, are an empirical, contextual outcome of contingent history, opening to the economist "a vast scope for theoretical imagination".

[6] And, the Buddhists would add, suffering deriving from desire, from having a utility function in the first place.

Satz and Ferejohn (1994) point out that rational choice theory is most credible under conditions of scarcity where human choice is constrained. Without constraints, agents will not behave as the theory predicts: "We need a background theory to identify in just which contexts a psychological interpretation of rational choice theory makes sense".

More recently, Amartya Sen (1999), the 1998 Nobel Laureate for economics, has criticized the assumptions that neo-classical economics makes about human cognition. It assumes a *Homo economicus*, the rational egoist driven by selfish motives. And it assumes the Paretan criterion: if the well-being of at least one individual increases, while the well-being of others does not decrease, then the general well-being increases. According to Sen, such assumptions about human behaviour are too narrow. Behaviour is not only motivated by selfishness, but also by other interests, such as the group interest, one's social position, ethics and so on. Instead of the deliberate fiction of *Homo economicus*, Sen pleads for a more pluriform approach that takes other motives into account.

In all, modern economics is struggling to move away from the axioms about cognition on which much of its theory is based. However, the fact that economics finds this struggle so difficult illustrates the stranglehold of its assumptions. The older strategic narratives of economics still guide ordinary people's expectations about human nature and are embedded in most of our institutions, such as political parties (Röling and Maarleveld, 1999). We have created environments that encourage people to act selfishly and strategically and have now reified this self-referential world to an extent where we cannot imagine venturing beyond it. Effectively dealing with the eco-challenge requires a deliberate program of economic research that allows us to embed paradigms and institutions based on 19th century economic rationality into a wider conception of ecological rationality. That indeed is the mission of ecological economics (O'Connor, 1998), not to be confused with environmental economics that tries to place environmental concerns within the confines of the neo-classical assumptions. For the time being, neo-classical economics provides a formidable restrictive insight with respect to both individual and collective behaviour.

At the collective level, the market is an arena of selfish individuals competing to gain access to scarce goods and services. The important assumption of neo-classical economics ever since Adam Smith and Jeremy Bentham is that the emergent property of this interaction is "the greatest good for the greatest number", hence an optimal allocation in conditions of scarcity. This leads to a restrictive insight that has provided the basis for an arrogant program of global societal design dominated by the IMF, the World Bank and business corporations. David Korten (1995) has formulated this restrictive insight as follows:

- People are by nature motivated primarily by greed;
- The drive to acquire is the highest expression of what it means to be human;
- Relentless greed and acquisition lead to socially optimal outcomes;
- It is in the best interest of human societies to encourage, honour and reward the above values.

These assumptions underpin the following "beliefs espoused by free-market ideologues" (Korten, 1995; 70):

- Sustained economic growth, as measured by gross national product, is the path to human progress;
- Free markets, unrestrained by government, generally result in the most efficient and socially optimal allocation of resources;
- Economic globalization, achieved by removing barriers to the free flow of goods and money anywhere in the world, spurs competition, increases economic efficiency, creates jobs, lowers consumer prices, increases consumer choice, increases economic growth and is generally beneficial to almost everyone;
- Privatization, which moves functions and assets from governments to the private sector, improves efficiency;
- The primary responsibility of government is to provide the infrastructure necessary to advance commerce and enforce the rule of law with respect to property rights and contracts.

Korten (1995) shows how these assumptions have legitimized the business corporations' role in destroying livelihoods and agro-ecosystems; in channelling wealth from the poor to the rich; and in undermining the vulnerable biosphere on which we all depend. Clearly neo-classical economics and its free market ideology provide for an untenable design of global society. Inventing a better design is the challenge ecological economics has set itself. But inventing such a design is obviously not just the task of economists. It is the next major global human project.

...And in agricultural economics?

It is interesting to note the thinking of our colleagues in agricultural economics who held their international association meeting in Berlin in August 2000 (Hedley, 2000; Bonnen, 2000). Such interest is warranted because of the role of agricultural economics in formulating and applying policies related to agriculture and agri-food systems. In his presidential address, Hedley states:

> Our profession is not defined centrally by disciplinary research in economics applied to agriculture, but by the synthesis of

> disciplinary and applied normative work in economics as well as the products of related disciplines such as history, law, sociology, psychology and political science for problem solving....the scope of our profession continues to widen to include and interface with new and emerging disciplines which contribute to problem solving throughout the entire food chain and governments.

Assuming that agricultural economics indeed has this all-embracing mandate, the question is whether we are in good hands from the point of view I have developed in this paper. I provide a few quotations that suggest the changing context *is* affecting restrictive insights. Hedley quotes Jones and Bureau (2000):

> Throughout the Uruguay Round of negotiations, there was wide acceptance and support for the intellectually comfortable notion that reducing trade barriers yielded increases in economic welfare for all parties. However, this conclusion can no longer hold as widely as before, and more careful consideration on a case-by-case basis particularly with respect to food quality and safety, is needed before determining whether trade liberalisation uniformly results in increased welfare.

But Hedley does not draw implications: "The GATT, and its evolution into the WTO, has been premised on the notion that lowering transaction costs in trade can lead to an improvement in economic well-being for all concerned." That is, market liberalization leads to the greatest good for the greatest number. And Hedley's concern turns to the removal of transaction costs and eventually to economic growth and expansion as the basis for "comparative investment climate across nations." So the untenable goals are firmly in place, with no mention of the eco-challenge.

But it does not sit easy. Says Hedley, referring to recent demonstrations in Seattle and Prague:

> The puzzle ...is how to create inclusive structures for policy formation....The economic implications for the agricultural economics profession around the world continue to change in response to this greater involvement of civil society, and with that, the task of communicating results from research and analysis on exceedingly complex topics must be undertaken. To fail in communicating with civil society, about the implications drawn from scholarly work in agricultural economics, our profession risks having decisions and directions based on incomplete information, not only by governments and international institutions, but also by the multitude of groups spawned by specific interests in society.... More active

approaches to reaching out to the citizenry are increasingly necessary for progress in policy decision-making.

Hedley's presidential address thus reminds us directly of Lubchenco's presidential address. Both the agricultural economists and the scientists see their future in telling us what is out there based on scientific research and scholarly work.

Bonnen's Elmhirst lecture (2000) presents some interesting complementary views. Of course, Bonnen also asserts that agricultural economics has had a critical role informing the decisions that adapt new technologies to human use.

> In agriculture, food, natural resource use and the environment today, agricultural economists are responsible to provide an understanding of the economic problems faced, the choices available and their consequences. We have a theoretical framework capable of helping to inform choices, including those that involve conflicting human values and institutions. First we must get the economics right. We must as a profession be prepared to develop expertise in new subject matters and bodies of theory, both in economics and beyond in other disciplines and subject matters, where we have little or no command or interest at present... We must put our policy analyses and advice in realistic contexts that policy makers can understand and respect.
>
> ...when the world economy and agriculture begin to change as fundamentally as at present, our professional capacity grows obsolescent....Governance issues and choices involve choosing who wins and who loses rights. This is always risky terrain. But we must plunge in, if we wish to make impact on the choices made. This involves redistribution, which is a political and moral, not just an economic decision....The profession's experience in development has demonstrated time-after-time that investments in non-market re-distributions are necessary before the market can work to capacity....The market alone is not able to extract the full potential of a development innovation without non-market re-distributive investments....We must recognise that some of the greatest advances in human welfare over the past century have been the product of re-distribution of rights: for example, anti-slavery laws, emancipation of women, and universal suffrage....We must, as a profession, be prepared to speak for those without a voice in agriculture as well as to puncture the windy rhetoric of economic nonsense.

Things are moving. The main impetus is the desire of agricultural economics to stay in the driver's seat. Given that, the context will largely determine the theory, the values and the actions. It will not be long before collective cognitive process to deal with the eco-challenge will be the core of agricultural economics.

Beta/Gamma science

A major departure from De Wit's restrictive insight is taking place in Wageningen (and many other agricultural universities): the spontaneous development of *beta/gamma* approaches in important agricultural science fields. *Beta* stands for the natural sciences and *Gamma* for the social sciences. Together, *Beta* and *Gamma* sciences are becoming increasingly involved in the interactive design of technology, farming systems, knowledge systems, natural resource use and other forms of land use negotiation (Leeuwis, 1999). Note that we do not talk of land use *planning* any longer (Brinkman, 1994).

The *Beta/Gamma* focus was not developed by social scientists. Doctoral students and maverick scientists in disciplines such as irrigation, entomology, forestry, soil and water conservation, ecology, and spatial planning began to take seriously 'the human factor' as a key ingredient of professionalism in their field. They recognized that delivery of science-based technologies to ultimate users such as farmers, simply does not work (Chambers and Ghildyal, 1985; Chambers and Jiggins, 1987). As a result, (and often in the face of conflict with the established positivist order), new issues and fresh perspectives emerged in several university departments (Box 1).

Box 1: *Examples of 'Beta/Gamma' areas that developed in originally purely technical (or 'Beta') departments (Röling, 2000)*

- *Irrigation*: the role of irrigators' associations in water management; farmer participation in irrigation scheme design and maintenance; resolution of conflicts between people at the head and tail of channels; social construction of technology, the repertoire of irrigation engineers.
- *Plant Breeding*: participatory plant breeding; *in situ* conservation of agro-biodiversity and the institutions required to sustain it; intellectual property rights; gender issues in managing plant genetic resources;
- *Bio-technology*: public acceptance; the social construction of technology; institutional conditions for beneficial use, for example, by small farmers.
- *Entomology*: Integrated Pest Management (IPM); Farmer Field Schools (FFS); community IPM; covenants for dealing with reductions in pesticide use;
- *Nature Conservation*: social fences; co-management; co-evolution with human communities;
- *Agronomy*: Farming Systems Research (FSR); ethno-botany; indigenous knowledge; Participatory Rural Appraisal (PRA); Participatory Technology Development (PTD); social determinants of recommendation domains; participatory planning with farmers of prototype farming systems;
- *Ecology*: adaptive management; social learning;
- *Spatial Planning*: interactive policy-making; participatory planning; platforms for resource use negotiation;

- *Forestry*: social forestry; community forestry; common property resource management; participatory Geographic Information System (GIS); indigenous knowledge; use of forest products by local people; forests as soft systems; certification problems;
- *Computer Science*: Multi-Agent Systems (MAS); using multi-object languages to simulate the interaction of cognitive agents in an environment.

We are still in the middle of these developments, and in the middle of trying to develop adequate curricula to prepare our graduates for *Beta/Gamma* tasks. Some professors still are reluctant to give up achievements hard won in positivist pursuits. Lest I am misunderstood, it is not their positivist pursuits I reject, but rather their rejection of other approaches as unscientific. I strongly believe in the usefulness of pure, laboratory, on-station, hard science, under positivist/realist assumptions.

The exciting thing is that a new additional area of science professionalism is emerging. When it comes to designing effective action in the domain of existence, pure science has an important role. But in addition, we have to deal with people's objectives and opinions as 'extended facts', with 'self-appointed activists' as extended peers (Funtowicz and Ravetz, 1993), and with shared cognitions, intentionality and institutions as essential ingredients in the interactive design of the future. In such design, people are not objects to be instrumentally or even strategically manipulated. They must participate. Agricultural science is, to a large degree, interactive (Röling, 1996). It is not natural laws that determine the direction in which natural systems evolve; this evolution is largely determined by human intentionality, agreement, conflict and, hopefully, forward-looking collaborative adaptive management (Buck *et al.*, in press).

Pathology of the collective cognitive system: the eco-challenge and mental health

In this analysis of collective cognitive systems and ecological rationality, I also examine pathology. I am aware of two examples.

A multi-disciplinary study, involving soil scientists and cultural psychologists, of villages in the Sahel concluded that environmental degradation is strongly related to stress and psychological marginalization (Van Haaften *et al.*, 1999). Environmental degradation was measured by soil depletion, loss of vegetation cover and soil erosion. A composite index based on these three measures was called environmental carrying capacity. Using established scales to measure psychological stress and psychological marginalization (defined as rejecting one's own culture as well as the new society one has become part of), a similar composite index for human carrying capacity was developed. The two indices

showed a correlation of .94, which means that 88 percent of the variance was explained. Comparative research for Chinese rural areas showed a lower but still substantial correlation (Van Haaften & Van De Vijver, pers. com). This research draws attention to structural coupling as a source of pathology, and suggests that such pathology could accelerate degradation by debilitating human agents to the extent that they do not take appropriate action.

Much earlier, Merton (1957) devised a classic typology of adaptation in situations in which cultural goals have changed, but institutionalized means have remained the same (Figure 6). Merton originally devised his scheme to explain deviant behaviour. It can also be read as a typology of effort to maintain cognitive consistency in the face of frustration, as a pathology of collective cognitive systems.

Mode of adaptation	new cultural goal	institutionalized means
1. Innovation	+	- -
2. Ritualism	- -	+
3. Retreatism	- -	- -
4. Rebellion	±	±
5. Conformity	+	+

Note: + means acceptance; - - means rejection; ± means rejection of prevailing values and the substitution of new ones.

Figure 6: Adaptations In Cognitive Change

(after Merton, 1957)

In terms of cognitive agents, we can describe the responses as follows (Röling, 1970):

- *Innovation*: taking action or having the ability to act so as to satisfy changed goals. Earlier, we called this control. Innovation might express itself in the adoption of new technologies, emigration, legal redistribution of access to assets and power, or even magic – developing supernatural means to achieve new goals.
- *Ritualism*: rejecting new goals to comply with the existing ability to act. Old forms of action are fixed, and this fixation is considered a substitute goal response. Development processes can lead to extreme traditionalism or fundamentalism, often an expression of frustration.
- *Retreatism*: rejecting the new goal *and* the existing ability to act. It represents withdrawal resulting in apathy. A typical response is fatalism, the belief that external forces determine outcomes; other responses include voluntary isolation and escapism into alcohol, cults, or religious

extremism. Such responses are often seen as the best solution to a hopeless situation. Seligman and Hager (1972) called this learned helplessness.

- *Rebellion:* rejecting the institutional arrangements within which the ability to act is defined (e.g., access to resources). In a way, rebellion is an innovative response.
- *Conformity:* adhering to both the new goal and the existing ability to act. This apparent paradox can be explained by the fact that people do not allow themselves to be motivated (and frustrated) by goals that they perceive as unrealistic (e.g., standards of living within higher income groups). Goals are limited to those perceived as attainable in one's own situation. One feels poor only in relation to the outcomes that one's reference group experiences.

Merton's typology highlights some interesting aspects of collective cognition.

1. Cultural goals are more prone to change than the opportunities to satisfy them. The subsequent tension underscores the importance of the human mechanisms that regulate motivation in view of realizable opportunity.
2. Global interconnectedness is increasing, yet so too is global inequality with respect to access to resources, capital and other opportunities, and enjoyment of benefits. Consequently, we may anticipate widespread deviant adaptations that threaten the achievement of a global system based on ecological rationality. The eco-challenge cannot be tackled without alleviating global inequalities and poverty.
3. If ecological rationality means adapting cultural goals to limitations in outcomes (i.e., taking less and/or giving more), cognitive inconsistency must be (self)managed to prevent pathological adaptations. This adaptation, in turn, implies reshaping criteria for status and achievement, new enthusiasms and new ideas about what is worthwhile, and perhaps new social institutional devices that replace the religion of old.

In all, the cognitive system pathologies suggest that environmental degradation and frustration can elicit adaptive responses that reduce the collective cognitive agents' ability to deal with ecological surprises.

Taking stock: the future is a human artefact

Humans have become a major force of nature (Lubchenco, 1998). The future is a human artefact. There is no god, science, or miraculous emergent property that is going to get us out of the eco-challenge. Unless we take it upon ourselves purposefully to grapple with the future, there won't be one. In that sense, we cannot opt out of science. But at the same time, as Einstein reminds us, we cannot get out of a problem by the same methods that got us into it. Hence the nature of science needs to change. The focus must shift from manipulating

things to reflectively learning to deal with our own behaviour. For example, everyone agrees there should be forests. But forests can only exist if people take purposeful concerted action to create and maintain them. The default is no forest (Keiter and Boyce, 1991; Röling, 2000).

The one element of praxis that can eradicate our current restrictive insights is change in *context*. As Kuhn (1970) established, a restrictive insight ("normal science", as he calls it) starts off by ignoring contextual signals that are inconsistent with it. Gradually, however, as the evidence becomes overwhelming, theory, values and action must adapt to context. Of course, many societies, such as the medieval Nordic communities in Greenland (Pain, 1993), have collapsed because they maintained their restrictive insights even in the face of evidence of their inadequacy. The insistence of elites on maintaining their lifestyles long beyond the time when it is prudent to do so is an important example of such irrational behaviour. The moneyed elites and corporations in the global economy can be expected to be formidable sources of resistance to change.

One important condition for change is for scientists to perceive the change in context and make it visible. That monitoring must reverberate throughout society and become a basis for social learning, if it is to be effective (Guijt, in prep.). If people are a major force of nature, and if the conditions for human life are threatened by collective human activity, then we must change human activity, not ecosystems. Or better, we must adaptively manage the structural coupling between human collective cognitive agents and the ecosystems on which they depend.

This conclusion has three major implications.

1. We cannot continue to consider the earth as a resource for only human activity and ends, and then rely on its resilience to deliver the ecological services that we as biological agents need. People have *de facto* taken responsibility for the direction in which the earth evolves. In this sense ecosystems, including the earth, have become soft systems (Checkland, 1981); whether by default or intention, their future states emerge from human interaction. This interaction requires deliberate management at the level of the ecosystems under threat.
   Such collective action makes special demands on the nature of human collective cognition. It requires shared sense-making, conflict resolution, negotiated agreement and accommodation, and deliberate concerted action among the stakeholders in the system. Our survival as a species no longer depends only on learning about our environment, but also on collectively learning about and controlling our own collective behaviour. Beck (1994) calls this necessity "reflexive modernization". We shall speak of 'social learning'. Social understanding has only marginally influenced science and public policy during the era in which people imposed increasing technical

control over the biophysical world. Now, however, understanding ourselves as a unique, reflexive, cognitive system is vitally important to our own survival.

This unprecedented change in context cannot be addressed by science or economics. It is a challenge for agricultural universities.

2. People's activities must increasingly be guided by ecological rationality. We must radically change our current rather single-minded pursuits of instrumental control and economic growth, and the institutions that foster this pursuit. In terms of the elements of praxis, we must change our fundamental values.
3. Humans must deliberately develop a soft side to the sustainable management of the biosphere (Röling, 1997; Jiggins and Röling, 1999). The soft side of land refers to the human knowledge, technology, institutions, resource allocation, and so forth from which land use emerges. This concept is illustrated by the following example from the Northern Philippines.

Box 2: *The Ifugao Rice Terraces as a monument to the soft side of land (Gonzalez, 2000)*

UNESCO has declared the 2000-year old rice terraces developed by the Ifugaos a Heritage Site. The sight of entire mountainsides covered by terraces awes the visitor, not only because of their beauty and the enormous effort that must have been involved in their construction, but also because of the ingenuity, organization and collective management that such a structure requires. Unlike the pyramids and other world wonders built by tyrants who used slaves for their own glory, the Ifugao terraces are due to voluntary collaboration and organization. Careful study reveals that the 'hard' terrace system of irrigation channels, walls, protective forests and so on, has its counterpart in complex social institutions and human cognition involving spirits and gods, rituals, work organization, discipline, leadership, shared experiential knowledge and values. The fact that the hard system now is collapsing can be traced to the erosion of the *social* system that ensured its upkeep.

People have always created their own world according to their shared enthusiasms. During the age of religion, they built cathedrals, mosques and temples and organized according to commands construed as given by god. In the industrial age, they embraced science through the emergence of actor networks that replicated laboratory findings on a societal scale (Callon and Law, 1989). Our current enthusiasm is to transform the whole world into a global, competitive marketplace dedicated to satisfying consumptive needs. But we have now entered a new context. We shall have to design a soft side of the Earth: new institutions, knowledge, learning processes, language and so on that allow humanity to tend the global garden. This is a hard thing to do, and the transformation required makes ours an exciting but also depressing future.

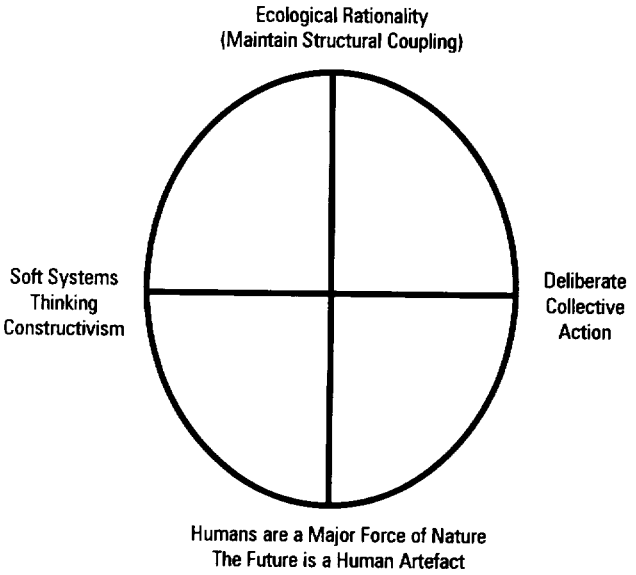

Figure 7: The Restrictive Insight Emerging from the New Context

Reasons for pessimism and for hope

The fact that we have international institutions which focus on establishing a global market, and that democratically elected governments assume that the free market is the best design for society at the regional, national and global level indicate that people are part of collective cognitive systems. Even when mobility was determined by the speed of the horse, collective enthusiasms such as Christianity and Enlightenment, swept throughout the world, greatly affecting how society was designed.

We must now learn to deliberately manage our collective cognitive systems themselves. Fundamentalism, be it Muslim, Christian, or neo-liberal, is a major threat to human survival because it detracts from responsiveness. The same can be said of corporations and other agents that have vested interests in the status quo. We have designed a highly inter-dependent soft side of the globe. Yet it is increasingly clear that the present set-up is very vulnerable. An increase of a few pennies in the price of fossil fuel leads to major upheavals, as we have seen recently. For example, the engines of Dutch fishing boats have become too powerful for sustainable fishing, and, with high fuel prices, too expensive to run, especially given the value of the fish that can be caught with them. The same appears to be true of the tractors that produce our cheap food. Our infra-structure, capital investment, organizations, marketing chains, insurance

systems and so forth increasingly seem to be built on quicksand and lack the resiliency to withstand climate change, let alone other major ecological surprises.

The resilience of the global human system depends on our ability to deliberately manage the collective cognitive system and the institutions that underpin it. This management means widely shared relativism with respect to the substantive content of our current enthusiasms and restrictive insights. The difficult question is how such readiness to change collective cognitive systems can be brought about. For example, most democratic societies accept that millions of dollars are being spent on elections or on advertising to increase consumption, but very few would accept deliberate use of public and commercial media to promote ecological rationality. In fact, the democratic process would prevent such use. An example is an advertising campaign undertaken by the Dutch Ministry of Agriculture to promote ecologically-produced food. Protests by conventional farmers ensured that the advertisements could not make comparisons between ecologically and conventionally-produced food. This restriction effectively undermined a major point of the campaign.

The resilience of collective human cognitive systems is a depressing political minefield. But the scene is not hopeless. One sign that seems to the possibility of positive change is the emergence of self-appointed activists, informal protest groups, NGOs, voluntary environmental organizations and nature conservation associations. They are usually supported by a generous public which feels that something is amiss, even though it may not know what to do about it. Such groups were able to temper the myopic efforts of the 2000 Seattle and Prague conferences to transform the world into a global market place. Continued generous funding of these groups by governments, foundations and the public is one condition for the emergence of a new order.

But there is more. The fact that people like me are beginning to buy into the ecological agenda, that corporate leaders are beginning to strategically take into account the uncertainties caused by the eco-challenge, and that the public is beginning to wake up means a gradual change in the mainstream. This change must eventually have political repercussions. It also means that research money is becoming increasingly available for forward looking studies that deal with the eco-challenge. I will give four examples of studies that I am involved in myself:

1. The European Commission has provided Euro 1.2 million for a study in five European countries that examines watershed management as the emergent property of multi-stakeholder interaction, how to effectively facilitate that interaction and the policy implications. The Dutch partners include my university and a commercial consultancy company that is already involved in the participatory management of water quantity and the transition from water retention to 'space for water'.

Similar proposals had been rejected three times before, but now the funding mechanism was receptive to the study. This new perspective has emerged because of recent freak weather events in Europe and their consequences (not to mention the fact that The Netherlands are slowly sinking, and the sea level is slowly rising).

2. Wageningen University has provided about Euro 250 000 for an interdisciplinary project called Convergence of Sciences: Inclusive Innovation Processes for Integrated Crop and Soil Management. The study involves technical and social scientists; includes farmers and other stakeholders in technology development (where technology is very broadly defined to include marketing, organization and collective action); and focuses not on a prescribed input base but on complex agro-ecological development. Hence the focus is not on developing the best technical means, but on generating learning systems to deal with intractable problems such as Striga parasitism of sorghum in West Africa.
3. The Dutch Ministry of Agriculture and the KNHM, a voluntary organization that emerged in the years of the great land reclamations and clearings, have provided seed money to promote effective discourse among rural and urban people about the use of green space. The Ministry, the KNHM and a provincial government that is involved all emphasized that they have funds for innovation in managing the land, and that they are looking for ideas on how to spend them. In fact, a move is underway to spend up to 10 percent of the public funds allocated to agricultural research to 'demand-driven research' formulated in regional 'knowledge centres'.
4. The Farming Systems Research Group of the French national research organization INRA is publishing a book (LEARN@Paris, in press) by a group of international scientists that focuses on how the 'agricultures' in industrial countries learn to deal with their new context. It was no problem to identify high quality contributions from all over the world.

As a result of these experiences, I am convinced that agricultural universities now have many opportunities. Their land use expertise can address the increasing public concern about the eco-challenge. It can also attract 'green' *beta/gamma* research funding, as well as the top students who are driven by issues instead of self-interest. Lubchenco's (1998) ideas about the eco-challenge as a new basis for a social contract for science apply especially to agricultural universities. If we miss the boat, it is because of our restrictive insights of yesteryear.

An agenda for agricultural and environmental research

Let me end this lecture by identifying some research issues that focus on transforming collective cognitive systems. I invite you to add to my list.

- *Eco-indicator development.* We currently use economic variables, such as inflation rate, GNP and the Dow-Jones Index as indicators of societal well-being. We have very few indicators of the eco-challenge, except perhaps the level of traffic pollution on inversion days and the quality of water for swimming. It is high time to develop indicators for the quality of the eco-systems and ecological services on which we depend.
- *Mechanisms involved in the governance of collective cognitive consistency.* The eco-challenge as a new context should lead to a new cognitive consistency. The governance mechanisms leading to such new consistency may be based on credibility, legitimation, collective simple heuristics (Gigerenzer *et al.*, 1999) that allow dismissal or acceptance of signals about the new context, and the perception of realistic alternatives for action. So far we have no overall shared theory that allows us to be aware of the mechanisms by which we tolerate inconsistencies and build new consistencies.
- *Facilitating collective action.* Innovation (e.g., sustainability) emerges from interaction among stakeholders (Engel and Salomon, 1997; Röling and Wagemakers, 1998). Rapid Appraisal of Agricultural Knowledge Systems (RAAKS) is a soft systems methodology that allows stakeholders to analyze their interaction so they can improve their innovative performance (Engel and Salomon, 1997). Considerable recent advances have been made in methods for large group interventions, such as open space technology (e.g., Holman and Devane, 1999; Bunker and Alban, 1997). But facilitating change (or change management) is only beginning to be a subject of (action) research and field experimentation, especially when collective action with respect to natural resource management is involved (Groot, in prep.; Groot and Maarleveld, 2000; Buck, 2000).
- *Corporate change management.* Much research has implicitly been directed at, or conducted with, public agencies. However, the predominance of the private sector means we must focus more on the private sector. Of course, many agricultural universities are already collaborating with the private sector by obtaining private funds for research that direct benefits the private sector. However, it is necessary to explore with the private sector opportunities for continuity in the new context. I assume that most corporations are more interested in continuity than short-term profit.

- *The interface between ecosystems and human institutions.* Some interesting research shows the importance of the "soft side of land'. But there is much about this issue that we do not understand. For example, agricultural research tends to focus on the farm level and to assume that farmers are the primary decision-makers in agriculture. This perspective obscures the larger social networks and institutions in which they are embedded and that to a large extent determine their choices.
- *Collective cognition and human institutions.* Mary Douglas (1986; 128) has expressed her distaste for the prevailing rational choice theory:

> Only by deliberate bias and by extraordinarily disciplined effort has it been possible to erect a theory of human behaviour whose formal account of reasoning only considers the self-regarding motives, and a theory that has no possible way of including community-mindedness or altruism, still less heroism, except as an aberration....For better or for worse, individuals really do share their thoughts and they do to some extent harmonise their preferences, and they have no other way to make the big decisions except within the scope of the institutions they build.

She sets out to amend such un-sociological views of human cognition and traces resistance to "the idea of a supra-personal cognitive system" to our society's enthusiasm for individualism. The commitment that subordinates individual interests to a larger social whole must be explained. Douglas therefore considers "the role of cognition in forming the social bond". The whole system of knowledge is a collective good that the community is jointly constructing. This process is centre of Douglas's book: "Half of our task is to demonstrate this cognitive process at the foundation of social order. The other half of our task is to demonstrate that the individual's most elementary cognitive process depends on social institutions" (45). Douglas (1996) has also been influential through her 'cultural theory' (reviewed by Oversloot, 1998). In brief, she argues that our preferences are largely the product of our social relations. Social relations are embedded in what Douglas calls "forms of social life that recur: the individualist, sectarian (or egalitarian) and hierarchical" (7). These forms of social life can be seen as a typology formed by two dimensions: group and grid. The former describes the extent to which individuals form part of bounded units, and the latter the extent to which the life of the individual is determined by rules. The resulting typology is shown in Figure 8. For Douglas, the typology has predictive value. For example, "the competitive (individualist) society celebrates its heroes, the hierarchy celebrates its patriarchs and the sect its martyrs" (80).

The possibilities of linking Figures 8 and 3 are intriguing. Does a techno-centric restrictive insight build on individualism? Does the holo-centric view, and its focus on co-operative choices implied in ecological rationality, assume subjugation of the individual to an agreed collective order or hierarchy?

- *Institutions and the perception of nature.* Thompson *et al.* (1990), quoted by Oversloot (1998), link the typology in Figure 8 to "myths of nature". Thus a perspective on nature as benign, robust and tolerant fits with individualism. Because it is robust, nature does not need protection. A view of nature as fairly tolerant, but perverse (if you treat it badly, the damage cannot be repaired) fits with hierarchy. Because nature must be handled with care, control by the group over individuals is required. Nature is extremely vulnerable (ephemeral) for egalitarians. It must be treated with extreme care. But egalitarians do not have the means to prescribe others how they should behave. The only thing they can do is to proselytize and lead an exemplary life. Finally, the idea that nature is capricious is consistent with fatalism, but also with spiritualism. In short, research on the possible link between "myths of nature" and cultural predilections seems relevant for our ability to deal with the eco-challenge.

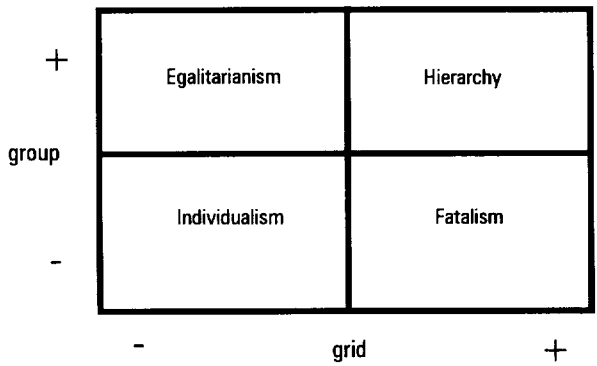

Figure 8: Typology of Forms of Social Life

(based on Oversloot (1998), and Douglas (1996)

Conclusion

My conclusion can be brief. The eco-challenge presents a unique opportunity for universities to provide leadership. But such leadership cannot be based on a narrow definition of life sciences as the search for the best bio-technological means. That is only more of the same and a sure road to marginalization. Biologists Maturana and Varela (1992) have opened an exciting perspective on cognition as the very process of life. An equally exciting new mission for agricultural science emerges if we define life sciences in that perspective.

This perspective moves life sciences far beyond its traditional positivist, controlled-oriented limits. Now the discipline expands to include the quadrants I, II and III in Figure 3 and to enhance the ecological rationality of the human project. Such an expanded perspective also goes beyond natural science, economics and other social sciences. And in doing so, it provides new insights that can help us successfully address the new context we find ourselves in.

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