THE PROSPECTS FOR IMPROVING SCIENCE-POLICY COMMUNICATION IN THE DESERTIFICATION REGIME: THE ROLE OF UNCERTAINTY*

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INTRODUCTION

Uncertainty, and how to communicate it to policy makers, is of growing concern in global change research (Dessaia et al., 2007). But whereas in the field of climate change the primary source of uncertainty is about the future, for desertification even past and present trends are highly inaccurate and strongly contested. Nevertheless, the two are related, since uncertainty about past and present trends in terrestrial variables included in global climate models affects uncertainty about future trends in climate and their impacts on the planet and its inhabitants.

So surely anything that scientists can do to use remote sensing and field observations to improve our knowledge of it must be a good thing and improve implementation of the UN Convention to Combat Desertification (CCD)? In practice, things are not as simple as this. I argue in this paper that uncertainty, and the ability of scientists and policy makers to reduce it, are connected in complex ways. That scientific uncertainty is not autonomous but socially constructed and politically contingent has been recognized for some time (Wynne, 1992).

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The first part of the paper looks at the relationship between uncertainty and constraints on communication between scientists and policy makers in the desertification regime, which consists of the binding CCD and the voluntary Plan of Action to Combat Desertification (PACD) which preceded it. This discussion is informed by reference to the Boundary Organization Model. The second part of the paper fits these constraints into a broader picture of uncertainty, framed by reference to the concept of post-normal science and a new Knowledge-Action Framework of science-policy communication. All three conceptualizations help scientists to stand back and view their roles as actors within the wider 'knowledge system' of desertification.

UNCERTAINTY

Uncertainty, for Smithson (1989), is a form of ignorance. There are two main types of ignorance, irrelevance and error, and the latter can be sub-divided into distortion (e.g. through confusion and inacccuracy) and incompleteness (which includes uncertainty). In the present context, these divisions are less clear, since incomplete data affect the accuracy of knowledge on which it is based. For Knight (1921), risk is a form of ignorance which can be assessed in terms of probabilities, while uncertainty cannot be assessed in this way.

In switching from 'first modernity' to 'second modernity' developed countries have, claims Beck (1992), become 'risk societies' which are subject to technologically derived risks of potentially huge magnitude with which political institutions are unable to cope. Contrary to Knight's (1921) definition, these risks cannot be calculated. Uncertainty and lack of scientific knowledge play their part in generating these new risks, as does inserting technologies into the social fabric (Latour, 1986) to reduce dependence on the natural environment and the hazards associated with this, Matten (2004) argues that 'symbolic politics' is fundamental to the "organized irresponsibility" which Beck uses to characterize the institutional failures of second modernity.

Developing countries are still subject to natural hazards as, by definition, they have not relinquished their intimate dependence on the natural environment. When people in developed countries assess the *global* environmental risks they face they are prone to imposing on developing countries their own contextualized perceptions, e.g. asserting that environmental management there is unsustainable precisely because of a lack of technological advancement. As a result, it is easy for people in developed countries to ignore the existence of often quite sophisticated coping mechanisms in developing

countries. They also fail to see the parallels between the two types of society: both are subject to uncertainty, the only difference is that one is natural and the other is technologically-derived!

DESERTIFICATION AND UNCERTAINTY

Desertification consists of "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (UN, 1994). It is recognized to be the result of a complex set of spatio-temporal processes (Grainger, 1992) involving multiple proximate causes and underlying driving (and controlling) forces, together with mediating factors and feedback loops (Geist and Lambin, 2004). Unfortunately, its contested nature and lack of data have limited systematic study. Robust theories and good empirical data with which to test them are essential if any area of land change science is to "move beyond the myths" (Lambin et al., 2001). This is especially true for desertification, which has even been condemned as a myth (see Thomas and Middleton, 1994).

One attempt to fill this gap, the Dahlem Desertification Paradigm, a set of nine assertions (Stafford Smith and Reynolds, 2002), has evolved into the Drylands Development Paradigm (DDP), which is a set of five principles (Reynolds et al., 2007). These characterize drylands as complex human-environment systems which:

1. Are coupled, dynamic and co-adapting.
2. Have critical dynamics determined by 'slow' (long-term) variables, though 'fast' (short term) variables generate 'noise' which can confuse researchers.
3. Have thresholds for slow variables beyond which systems can move into new states.
4. Are multi-level, nested and networked with hierarchical links and cross-scale interactions.
5. Require both scientific and contextual knowledge for a comprehensive understanding.

Uncertainty in science is of most concern in "science for decision-making", e.g. in such fields as desertification and global climate change, as opposed to "discovery-driven basic research", where - in the natural sciences at least - scientists have more control over data collection (Mossa, 2007). This is ironic since policy makers commonly believe that it is the job of scientists to reduce uncertainty! A distinction has been made between uncertainty linked to models of trends as opposed to that resulting from conflicts between the opinions of different experts (Patt, 2007) though, as we have argued above, the former can be linked to the latter.

Uncertainty in desertification seems to be an inevitable consequence of the complexity of human-environment systems in the drylands. While the word 'uncertainty' is mentioned a few times by Reynolds et al. (2007), it is not prominent in the DDP, though it is implied in references to frequent confusion between slow and fast variables (Principle 2), and the need for comprehensive knowledge to draw on perceptions of multiple sources at multiple scales (Principle 5).

One crucial contributor to uncertainty that is missing from the DDP is the high spatial and temporal variability which is an important feature of dryland environments and their degradation (Tiffen and Mortimore, 2002). This makes it difficult to assess degradation at national, regional and global scales (Principle 4). High spatial and temporal variability in precipitation results in similar variability in vegetation growth and human and animal exploitation of primary productivity. This leads to complex interactions between real degradation, 'apparent degradation' (expressed in temporary fluctuations in biomass), and human responses, whether these be overexploitation, diversification or withdrawal. Indeed, mobility/migration is another geographical feature that is not prominent in the DDP but vital to both customary social coping mechanisms, e.g. by pastoralists, and emergency responses to drought, as when farmers migrate to cities to sustain their livelihoods (Bradley and Grainger, 2004). Nor should the complex relationships between soil and multi-layer vegetation systems, and their degradation, be downplayed. Indeed, the sheer diversity of possible responses to spatial and temporal variability in dryland conditions is another source of uncertainty as it precludes simple explanations. So while the DDP is a good starting point for systematic study it is not comprehensive. Nor - to their credit - do its authors pretend that it is.

The reason for placing so much stress on uncertainty in desertification is the possibility that it may well be inherent in the phenomenon itself. Uncertainty about desertification has been high for thirty years and, despite some optimistic claims (e.g. Veron et al., 2006), it does not seem to be declining. We may be gaining more insights into the processes by which it occurs but we still lack reliable estimates of the true magnitude of the phenomenon and the rate at which it is changing. Part of the reason for this is undoubtedly the complexity of the phenomenon itself. We still lack reliable estimates of the rate of tropical deforestation, even though this phenomenon is relatively simple in comparison with desertification. A key source of uncertainty in the case of tropical deforestation is the difficulty involved in assembling estimates of the scale of the phenomenon in different countries to produce a global estimate (Grainger, 2007a). However, for desertification the complexity of change even within countries means that the difficulty of monitoring it is several orders of magnitude higher. Over and

above these constraints, I argue in this paper, are the limitations imposed by policy makers on scientists who are supposed to be supplying them with knowledge.

CONSTRAINTS ON SCIENCE-POLICY COMMUNICATION IN THE DESERTIFICATION REGIME

The Place of Knowledge in Policy Formulation

Recent discussions about good practice in policy formulation have stressed the importance of evidence-based policy-making, in which policy makers expose themselves to as much scientific evidence as possible before taking decisions (Fig. 1) (Cabinet Office, 1999). This assumes that knowledge is separate from how it is used by those in positions of power. It also has strong resonances with rational models of policy formulation, despite John's (1998) criticism that it is invalid to set up a dichotomy between such models, in which policy makers select from a wide range of policy options by means of some rational calculus that considers what is best for society, and behavioural models, in which the interests of policy makers themselves are to the fore and ensure that policy only changes incrementally.

As I argue in more detail elsewhere (Grainger, 2007b), the Parties to the CCD, and the PACD before it, have actually only allowed a small proportion of all scientific knowledge on desertification to reach them, channelled by small groups of experts whom they select. It is as if they have placed a barrier between themselves and scientists, and only allow knowledge to percolate through a small hole in it (Fig. 2).

One result of the desertification regime's reliance on a small group of experts, and its isolation from the wider scientific community, is that a feedback loop to the science domain has evolved which has promoted divisions within the scientific community on the meaning, and even the validity, of desertification, leading to the widespread acceptance of a "denial discourse" (Adger et al, 2001) which itself has created uncertainty. Empirical data collected by scientists outside the select expert community appeared initially to challenge the validity of desertification. More recently, these explanations have themselves been challenged (see Grainger, 2007b). Such insularity has not only weakened the desertification regime, it has also contributed to a lack of detailed monitoring of desertification, by remote sensing and ground observation, which could have provided data that would

have reduced the uncertainty about the phenomenon that has persisted for thirty years.

Features of the CCD's Organization of Science-Policy Communication

In the organization of science policy communication in the CCD, the Conference of the Parties (COP) gives responsibility for discussing scientific matters to a Committee on Science and Technology (CST), which in turn is advised by a Group of Experts (GOE) (Fig. 3). This 'expert model' of science policy communication was also employed in the PACD. It contrasts with the 'network model' used in the climate change regime, in which the equivalent body to the CST is advised by a large and diverse global network of scientists that form the Intergovernmental Panel on Climate Change (IPCC).

Poor science policy communication has been criticized by the COP for many years (e.g. COP, 2001), and by a more recent report by the UN Joint Inspection Unit (JIU) (Ortiz and Tang, 2005). It is apparent in very practical ways in the lack of an effective set of indicators which the COP could use to monitor the extent and rate of spread of desertification and progress in reducing this by implementing the CCD.

Another JIU criticism is that the developing and developed country parties to the CCD have different perceptions about its goals: developed countries are said to regard it as primarily a mechanism to conserve the global environment, while the priority of developing countries is to reduce constraints on development imposed by frequent droughts. Policy ambiguity, a form of symbolic politics (Matten, 2004) in which the actual policy of a government is very different from the policy that it states in official publications, is well known in national policy analysis (Aucoin, 1971). It also appears in voluntary international environmental agreements, such as the PACD: governments can sign up to ambitious goals in the knowledge that there will be no repercussions if they do nothing to try to realize them within their own countries. Ambiguity is also at the heart of diplomatic interchange. It is supposed to be precluded by binding international agreements, but the example of the CCD shows that this cannot always be guaranteed. There are parallels here with Matten's (2004) suggestion that the exercise of symbolic politics is fundamental to the 'organized irresponsibility' of 'risk society'.

In my view, these two criticisms are linked: if the sustainability of the CCD does indeed depend on maintaining this ambiguous understanding of its goals, better science policy communication would puncture this ambiguity and thereby undermine the sustainability of the CCD.

COMPARISONS WITH THE NORMATIVE BOUNDARY ORGANIZATION MODEL

According to the Boundary Organization Model (BOM) (Cash et al., 2003), communication between the scientific domain and the policy domain is ideally facilitated by intermediary organizations called boundary organizations. The notion of a boundary, mutually constructed by scientists and policymakers to privilege scientific knowledge over other forms of knowledge, was originally devised within a constructivist approach (Guston, 1999), which seeks to penetrate below surface structures to identify those beneath (Alvesson and Sköldberg, 2000). Boundary organizations involve representatives from the two domains and, crucially, are ideally responsible to both domains.

Boundary organizations are, in the BOM, effective institutional spaces (Fig. 4). To turn scientific knowledge into action they optimize its salience, legitimacy and credibility through three functions: communication; translation from scientific language into ordinary language; and mediation, which can reduce the conflicts that arise when making trade-offs between salience, legitimacy and credibility.

When we compare what happens in the CCD to the normative framework of the BOM, we find that the CCD has two boundary organizations, the CST and the GOE (Fig. 5). These are both responsible to the Conference of the Parties but are not responsible to the wider scientific community. Members of the GOE are selected by governments. By the terms of the CCD, inserted at the insistence of developing country Parties (Kjellén, 2003), the CST consists of government representatives, and so it effectively acts as a gatekeeper between the GOE and the COP.

Another difference from the BOM - which also reflects the latter's own limitations - is that the Parties to the CCD have different perceptions of its goals. If its boundary organizations are to translate scientific knowledge into a language acceptable to both developed and developing country parties then two parallel and incompatible texts are required. In the BOM, boundary organizations produce texts called 'boundary objects' which combine scientific texts and vernacular texts and so are acceptable to both scientists and policy makers. It is a short - but nevertheless crucial - step from this to adding another layer of text to meet the needs of a separate group of policy makers. The concept of desertification is thus an ambiguous boundary object that has maintained the commitment of the Parties to the regime since the 1970s.

So why does science-policy communication in the desertification regimes differ so much from the ideals of the BOM? International regimes, such as the desertification regime, are collections of institutions, or rules, as boundary organizations themselves are supposed to be. Yet the set of institutions in each regime are those agreed by its Parties, and they do not have to include all the institutions needed for an effective boundary reorganization, as prescribed by the BOM. So with only a partial institutional space it is not surprising if the functioning of boundary organizations does not meet expectations. In the desertification regime the entry rules agreed by its Parties only allow a small number of scientists to provide knowledge inputs. Other rules pre-empt the process of optimization, by privileging political legitimacy, achieving salience through ambiguity, and giving low priority to scientific credibility.

Such an approach is naturally unacceptable to the wider scientific community, which privileges clarity over ambiguity, and changes its theories as new empirical facts are discovered. A similar approach in the PACD helps to explain how a divide arose in the 1980s between the experts invited into the 'inner sanctum' of the desertification regime and the vast majority of scientists who were not, and who thought that available data did not support what the UN Environment Programme (UNEP) was communicating about desertification. In their eyes, the data revealed high spatio-temporal variability in desertification; this was not compatible with simplistic explanations promoted by UNEP, such as the continuous and irreversible 'frontier expansion' of deserts. As the scientists who favoured this denial discourse were external to the regime, its boundary organizations were not obliged to mediate to resolve the conflict between them and actors in the regime.

When the world's governments negotiated the CCD they had no access to this large body of sceptical scientific opinion. Even today, the COP can only receive scientific information from its CST or from its Parties. A quote from a CST (2003) document illustrates this perfectly:

> "For decades a high [*sic*] number of scientific studies on desertification have been carried out ... However, it seems ...very difficult to have access to these valuable data, as almost all countries do not dispose of a complete national survey of results of their projects and programmes related to desertification."

DESERTIFICATION AS A POST-NORMAL PHENOMENON

Post-Normal Science

In the light of these constraints, how can we improve science-policy communication in the CCD? It seems from our discussion so far that desertification is contested by politicians, contested by scientists, spatially and temporally variable, and highly uncertain in scale and rate of change. Perhaps we should start from the assumption that all of these things are not chance occurrences but interconnected. Funtowicz and Ravetz (1993, 1994) argued that conflicting stakeholder interests, great uncertainty and high decision stakes are all features which make a phenomenon unsuited to being studied by 'normal' science, which is typically reductionist, highly compartmentalized by discipline, and usually positivist. Instead, it is best studied by 'post-normal' science, which takes a transdisciplinary and multi-scalar participatory approach that recognizes the subjectivity and plurality of knowledge. Since desertification satisfies all of the criteria for a post-normal phenomenon, in this section I use this as a basis for further analysis.

While one of its originators feels that it is now "approaching obsolescence" (Ravetz, 2006), the concept of post-normal science is still informing research in environmental ethics (Westra, 1997), climate change (Saloranta, 2001), ecological economics (Müller, 2003), statistics (Zideki, 2006) and sustainable forest management (Swedeen, 2006). It is of particular value when science is called on to provide knowledge to assist in solving societal problems (so there are links to uncertainty in "science for decision-making" referred to above) and has been termed a special case of 'Mode-2 science' (Müller, 2003). The adjective 'post-normal' derives, in my view, from a misreading of Kuhn's (1970) notion of a 'normal' science. But as the basic concept seems valid and the term is in current use I retain it here.

Discursive Space

Long-Martello (2004) has argued that to improve science-policy communication in the CCD, and the effectiveness of its implementation, a more participatory approach should be adopted. The CCD is too centralized at the moment, and must be decentralized, she claims, so that scientists and stakeholders are better able to co-produce knowledge at all spatial scales. If we take a post-normal approach, however, contestation between stakeholders at different spatial scales is only *one* of the changes

needed. It is also important to involve more scientific disciplines and allow scientists to work across disciplines to devise more appropriate explanations of the phenomenon of desertification.

From the perspective of a Knowledge-Action Framework devised by this author (Fig. 6), greater involvement of stakeholders at different spatial scales will improve vertical plurality along one axis of *discursive space*, while complementary changes to ensure disciplinary diversity and inter- and trans-disciplinarity will improve *horizontal plurality* along the other axis. The concept of discursive space emerges from a post-structuralist approach (Campbell, 2007), in which the narratives constructed by any actor to explain a phenomenon are framed within their discourse. A discourse is a "a specific ensemble of ideas, concepts, and categorizations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer, 1995). Discourse analysis is now often used as a tool in environmental policy analysis (Sharp and Richardson, 2001). It helps in this context to explain how ambiguous boundary objects function (Fig. 5) - each group of states only recognizes the text containing terms found in its particular discourse.

Each discipline constructs knowledge within its own discourse of terms and relationships. Stakeholders at different spatial scales also construct knowledge differently within their own discourses, which have evolved through long experience of the environments they inhabit. The multiplicity of cells in discursive space that result from intersections between the rows that represent stakeholders, and the columns which represent disciplines, show the potential for contesting a different phenomenon. They also indicate the uncertainty that can arise when just a few disciplines predominate in explaining the phenomenon and are supplemented by only a limited amount of contextual knowledge from stakeholders at different spatial scales. The notion of discursive space gives a simple, but in our view convincing, theoretical explanation for the concept of post-normal science which, to the best of our knowledge, has not been offered before.

Institutional Space

Institutions are tremendously important in society. They have already appeared here in the form of international regimes and boundary organizations, and can be defined generically as "enduring regularities of human action in situations structured by rules, norms and shared strategies, as well as by the physical world" (Crawford and Ostrom, 1995). A number of different schools have arisen independently to offer theoretical explanations (Hall and Taylor, 1996). Institutions provide an

excellent illustration of the difficulty of giving priority to either structure or human agency in social phenomena. The middle way between this dualism is provided by Giddens (1984), in whose structuration theory institutions are continually reproduced by the human beings who conform to them.

Institutions differ from organizations, but are found within them. They help to explain why state organizations frequently have difficulty in implementing government policies effectively (Hill and Hupe, 2002). The operations of these organizations are constrained by internal institutions, and also by institutions in the societies which they are attempting to regulate.

The difficulties involved in implementing an international regime can also be understood from this perspective. Institutions agreed by all countries at global level must, for successful implementation, be reproduced at each successively lower spatial scale until we reach the local. Yet at each scale there are already well established institutions, sometimes the result of centuries or more of reproduction. They will resist being modified or replaced by new institutions imposed from above, particularly if these lack the contextual perceptions of reality at each spatial scale. The possibilities for such contest are shown by the multiplicity of cells that result from the intersections of rows, representing spatial scales as before, and columns, now representing the institutions in each country, in the *institutional space* that is the other component of the Knowledge-Action Framework (Fig. 6).

Knowledge-Action Framework

The difficulties of communicating scientific knowledge to policy makers so it is turned into action on the ground becomes apparent when discursive and institutional spaces are superimposed, which they are in the Knowledge-Action Framework (Fig. 6). This follows the argument of Foucault (1979) in treating power and knowledge as inseparable.

Since institutions are the 'glue' which holds society together and sustains particular societal configurations, it seems self-evident that they help in some way to sustain the discourses which are another continuing societal phenomenon, whether this involves perpetuating particular religious doctrines or scientific disciplines. Yet the relationship between discourse and institutions is contested. For Barnett and Duvall (2005) the two are mutually exclusive. A poststructuralist approach which we adopt here, however, treats the relationship as dialectical, e.g. "the discursive event is shaped by

situations, institutions and social structures, but it also shapes them" (Fairclough and Wodak, 1997).

The reason why developing countries placed restrictions on the role of scientists in the CCD now becomes clearer. If scientists from a few disciplines at the global level (i.e. 'experts' selected by international organizations to make global generalizations) were to communicate their limited knowledge to the COP they would miss much of the contextual knowledge at lower scales. It is as if the discursive and institutional spaces were turned around so that the only links between them were via their global levels (Fig. 7). For this reason it is understandable that developing countries seek to place some limits on this. Government representatives on the CST therefore act as proxies for national and sub-national stakeholders to balance the knowledge constructed by scientists at global level.

CONCLUSIONS

Uncertainty, according to this analysis, seems to be inherent in desertification and so qualifies it to be regarded as a post-normal phenomenon. Uncertainty is is exacerbated and sustained by interactions between scientists and policy makers in the desertification regime. The Knowledge-Action Framework helps to explain the reasons for this.

How can we reduce uncertainty about desertification and improve our ability to combat it? At the very least the CCD should replace the expert model of science policy communication by a larger inter- and transdisciplinary network model. One option would be to establish an equivalent of the Intergovernmental Panel on Climate Change (IPCC), i.e. an Intergovernmental Panel on Desertification which contained a large number of scientists from a diversity of disciplines. Another would be to forge a link to the IPCC itself, as it already contains many scientists who could fulfil such a role. However, the first option may not be politically feasible, as radical changes to the text of the CCD could break up the fragile ambiguous consensus on which its sustainability relies. The second option may not be feasible either, as the FCCC has rebuffed previous attempts by the CCD to establish closer scientific links with it. The FCCC's reticence may well be due to its concern about the lack of a proper science base in the CCD.

This leaves, in my view, four avenues for constructive change. First, the community of scientists working on arid lands, and their role in global change generally, could *themselves* create such a network. This would have the autonomy and authority to provide reliable advice to any international

initiative to combat desertification, whether this be the CCD or some future venture.

Second, since desertification has, right from the start, been a politicized concept I believe it should be abandoned by the scientific community and replaced by 'dryland degradation'. This would not be a mere change in terminology, but remove completely the ambiguous understanding of desertification which is at the root of current uncertainty about it and the lack of progress in implementing the CCD, reflecting the inseparability of power and knowledge in this field.

Third, attaining greater clarity on the environmental change component of desertification should not be at the expense of the desire of developing countries to 'develop'. Unfortunately, the concept of sustainable development that was the motivating principle behind the UN Conference on Environment and Development in 1992 and was delineated in the Agenda 21 document (UN, 1993) cannot provide a suitable alternative to 'desertification' or its developmental dimension, for it is just as ambiguous as desertification itself (Grainger, 2004). Since the CCD was formulated within the framework of sustainable development and the definition of desertification contained in Agenda 21 this is not surprising. What is needed instead is for the developed countries to recognize that the aspirations of developing countries for 'development' should be on *their* terms and not those imposed on them by developed countries. This requires a new international consensus, though whether this is possible, given the difficulties which the two sets of countries have in understanding each other's social, economic, and environmental and political conditions (Grainger and Konteh, 2007), is debatable.

Fourth, the one immediate hope for a new political bargain to be struck between developing countries and developed countries on dryland degradation is as part of forthcoming negotiations on the successor to the Kyoto Protocol. One aim of these negotiations will be to secure the participation of developing as well as developed countries, and as this is also a key requirement for the USA to ratify "Kyoto II" it will undoubtedly be given a high priority in discussions. In fact, the US Government has itself proposed tackling desertification within the climate change regime (SBSTA, 2006). Dryland degradation is actually just one of many dimensions of land degradation linked to climate variability and long-term climate change. So the two would fit together nicely. The key advantages of including dryland degradation in Kyoto II are that: (a) the flow of financial assistance to developing countries would now be based not upon ambiguity but upon the principle of compensation for the developed countries' contribution to global climate change by their long-standing emissions of greenhouse gases; and (b) the prospects for meaningful action to combat dryland degradation would be excellent, as the

climate change regime is, by comparison to the CCD, highly specific and unambiguous, and heavily science-based. Within a few years' time, therefore, the results of research by the new autonomous network of arid lands scientists would be very much in demand.

REFERENCES

Adger W.N., Benjaminsen T.A., Brown K. and Svarstad H., 2001. Advancing a political ecology of global environmental discourses. *Development and Change* **32**: 681-715.

Alvesson M. and Sköldberg K., 2000. *Reflexive Methodology: New Vistas for Qualitative Research*. Sage, London.

Aucoin P. (ed.), 1971. *The Structures of Policy Making in Canada*. Macmillan, Toronto.

Barnett M. and Duvall R., 2005. Power in global governance. In Barnett M. and Duvall R. (eds.). *Power in Global Governance*: 1-32. Cambridge University Press, Cambridge.

Beck U., 1992. *Risk Society: Towards a New Modernity*. Sage, London.

Bradley D. and Grainger A., 2004. Social resilience as a controlling influence on desertification in Senegal. *Land Degradation and Development* **15**: 451-470.

Cabinet Office, 1999. *Policy Making for the 21st Century*. Her Majesty's Stationery Office, London.

Campbell D., 2007. Poststructuralism. In Dunne T., Kurki M. and Smith S. (eds.). *International Relations Theories: Discipline and Diversity*: 203-228. Oxford University Press, Oxford.

Cash D.W, Clark W., Alcock F., Dickson N., Eckley N., Guston D., Jager J. and Mitchell R., 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences* **100**: 8086-8091

COP, 2001. Implementation of the Convention. Synthesis of the report on ways of improving the efficiency and effectiveness of the Committee on Science and Technology. Addendum. Conference of the Parties at its 5th Session. ICCD/COP(5)/3/Add.2, 3 September 2001. UN Convention to Combat Desertification, Bonn

Crawford S.E. and Ostrom E., 1995. A grammar of institutions. *American Political Science Review* **89**: 582-600

CST, 2003. Programme of Work of the Committee on Science and Technology. Synthesis of report submitted by Parties on case studies illustrating best practices and innovative research relating to land degradation vulnerabilities and rehabilitation: an integrated approach. Committee on Science and Technology, 6th Session, Havana, 26-28 August 2003. ICCD/COP(6)/CST/2, 4 July 2003. UN Convention to Combat Desertification, Bonn.

Dessaia S., O'Brien K. and Hulme M., 2007. On uncertainty and climate change. *Global Environmental Change* **17**: 1-3.

Fairclough N. and Wodak R., 1997. Critical discourse analysis. In Van Dijk T. (ed.). *Discourse as Structure and Process*: 258-284. Sage, London.

Foucault M., 1979. *Discipline and Punish: The Birth of the Prison*. Vintage, New York.

Funtowicz S.O. and Ravetz J.R., 1993. Science for the post-normal age. *Futures* **25**: 735-755.

Funtowicz S.O. and Ravetz J.R., 1994. The worth of a song bird: ecological economics as a post-normal science. *Ecological Economics* **10**: 197-207.

Geist H.J. and Lambin E.F., 2004. Dynamic causal patterns of desertification. *Bioscience* **54**: 817-829.

Giddens A., 1984. *The Constitution of Society*. Polity Press, Cambridge.

Grainger A., 1992. Characterization and assessment of desertification processes. In Chapman G.P. (ed.). *Proceedings of Conference on Grasses of Arid and Semi-Arid Regions*, Linnean Society, London, February 1991: 17-33. John Wiley, Chichester.

Grainger A., 2004. Sustainable development and international relations. In Purvis M. and Grainger A. (eds.). *Exploring Sustainable Development: Geographical Perspectives:* 279-312. Earthscan Publications, London.

Grainger A., 2007a. The influence of end-users on the temporal consistency of an international statistical process: the case of tropical forest statistics. *Journal of Official Statistics* (in press).

Grainger A., 2007b. Problems with boundary management: explaining deficiencies in scientific inputs to the global desertification regime. *Land Degradation and Development* (submitted).

Grainger A. and Konteh W., 2007. Ambiguity, autonomy and symbolism in African politics: the development of forest policy in Sierra Leone. *Land Use Policy* **24**: 42-61.

Guston D., 1999. Stabilizing the boundary between US politics and science: the role of the Office of Technology Transfer as boundary organization. *Social Studies of Science* **29**: 1-25.

Hajer M.A., 1995. *The Politics of Environmental Discourse. Ecological Modernization and the Policy Process*. Clarendon Press, Oxford.

Hall P.A. and Taylor R.C.R., 1996. Political science and the three new institutionalisms. Political Studies, 44, 936-957.

Hill M. and Hupe P., 2002. *Implementing Public Policy*. Sage, London.

John P., 1998. *Analysing Public Policy*. Continuum, London.

Kjellén B., 2003. The saga of the Convention to Combat Desertification: the Rio/Johannesburg process and the global responsibility for the drylands. *Review of European Community and International Environmental Law* **12**(2): 127-132.

Knight F.H., 1921. *Risk, Uncertainty and Profit*. Kelley, New York.

Kuhn T.S., 1970. *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago.

Lambin E.F., Turner B.L. II, Geist H.J., Agbola DS.B., Angelsen A. et al., 2001. The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change* **11**: 261-269.

Latour B., 1987. *Science in Action*. Harvard University Press, Cambridge.

Long Martello M., 2004. Expert advice and desertification policy: past experience and current challenges. *Global Environmental Politics* **4**: 85- 106.

Matten D., 2004. The impact of the risk society thesis on environmental politics and management in a globalised economy - principles, proficiency, perspectives. *Journal of Risk Research* **7**: 377-398.

Mossa R.H., 2007. Improving information for managing an uncertain future climate. *Global Environmental Change* **17**: 4-7.

Müller A., 2003.A flower in full blossom? Ecological economics at the crossroads between normal and post-normal science. *Ecological Economics* **45**: 19-27.

Ortiz E.F. and Tang G., 2005. Review of the Management, Administration and Activities of the UN Convention to Combat Desertification (UNCCD). Joint Inspection Unit, United Nations, Geneva.

Patt A., 2007. Assessing model-based and conflict-based uncertainty. *Global Environmental Change* **17**: 37-46.

Ravetz J.R.,2006. New perspectives on post-normal science: contradictions and sustainability. Essay prepared for the Workshop on Transitions to Sustainable Development: Complexity, Co-evolution and Governance, 20-24 November, 2006, Egmond, Netherlands.

Reynolds J.F., Stafford Smith D.M., Lambin E.F., Turner B.L. II, Mortimore M., Batterbury S.P.J., Downing T.E., Dowlatabadi H., Fernández R.J., Herrick J.E., Huber-Sannwald E., Jiang H., Leemans R., Lynam T., Maestre F.T., Ayarza M. and Walker B., 2007. Building a science for dryland development. *Science* **316**: 847-851.

Saloranta T.M., 2001. Post-normal science and the global climate issue. *Climatic Change* **50**: 395-404.

SBSTA, 2006. Views on the paper on options for enhanced cooperation among the three Rio conventions. Subsidiary Body for Scientific and Technological Advice, 24th Session, Bonn, 18-26 May, 2006. FCCC/SBSTA/2006/MISC.4. Framework Convention on Climate Change, Bonn.

Sharp L. and Richardson T., 2001. Reflections on Foucauldian discourse analysis in planning and environmental policy research. *Journal of Environmental Policy and Planning* **3**: 193-209.

Smithson M., 1989. *Ignorance and Uncertainty: Emerging Paradigms*. Springer Verlag, Berlin.

Stafford-Smith D.M. and Reynolds J.R., 2002. Desertification: a new paradigm for an old problem. In Reynolds J.R. and Stafford-Smith D.M. (eds.).*Global Desertification: Do Humans Cause Deserts?* : 403-424. Dahlem University Press, Berlin, Germany.

Swedeen P., 2006. Post-normal science in practice: a Q study of the potential for sustainable forestry in Washington State, USA. *Ecological Economics* **57**: 190-208.

Thomas D.S.G. and Middleton N.J, 1994. *Desertification: Exploding the Myth*. John Wiley, Chichester.

UN, 1993. *Agenda 21*. United Nations, New York.

UN, 1994. *Elaboration of an International Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa*. Final Text of the Convention. United Nations General Assembly, A/AC.241/27, 12 Seprtember 1994. United Nations, New York.

Veron S.R., Paruelo J.M. and Oesterheld M., 2006. Assessing desertification. *Journal of Arid Environments* **66**: 751-763.

Westra L., 1997. Post-normal science, the precautionary principle and the ethics of integrity. *Foundations of Science* **2**: 237-262.

Wynne B., 1992. Uncertainty and environmental learning: reconceiving science and policy in the preventative paradigm. *Global Environmental Change* **2**: 111-127.

Zideki J.V., 2006. (Post-normal) statistical science. *Journal of the Royal Statistical Society A* **169**: 1-4.

Figure 1.Evidence-based policy making

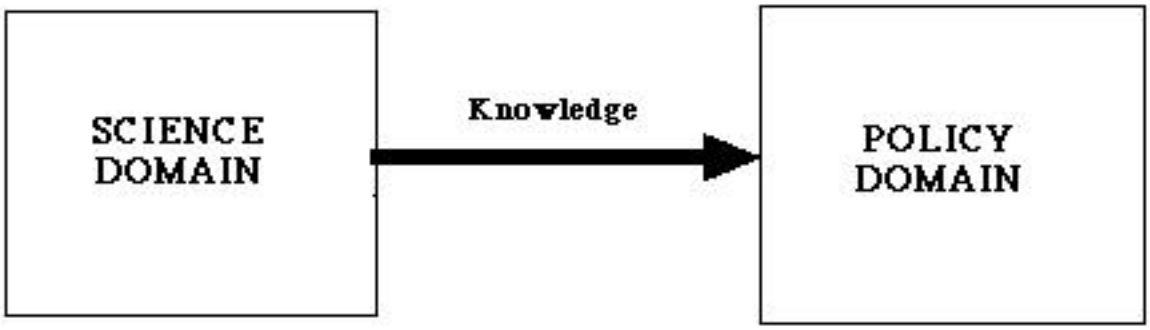
SCIENCE
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Figure 2. The barrier to science-policy communication in the desertification regime

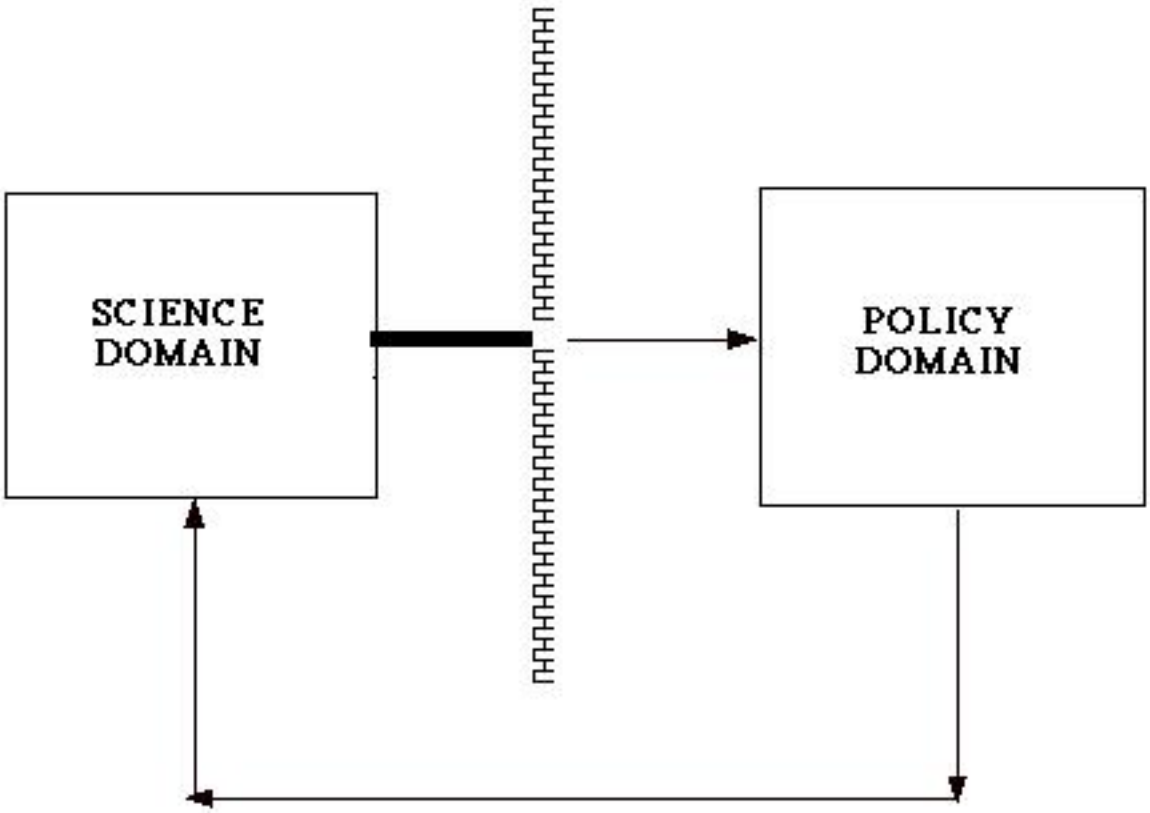
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Figure 3. The present organization of science-policy communication in the UN Convention to Combat Desertification

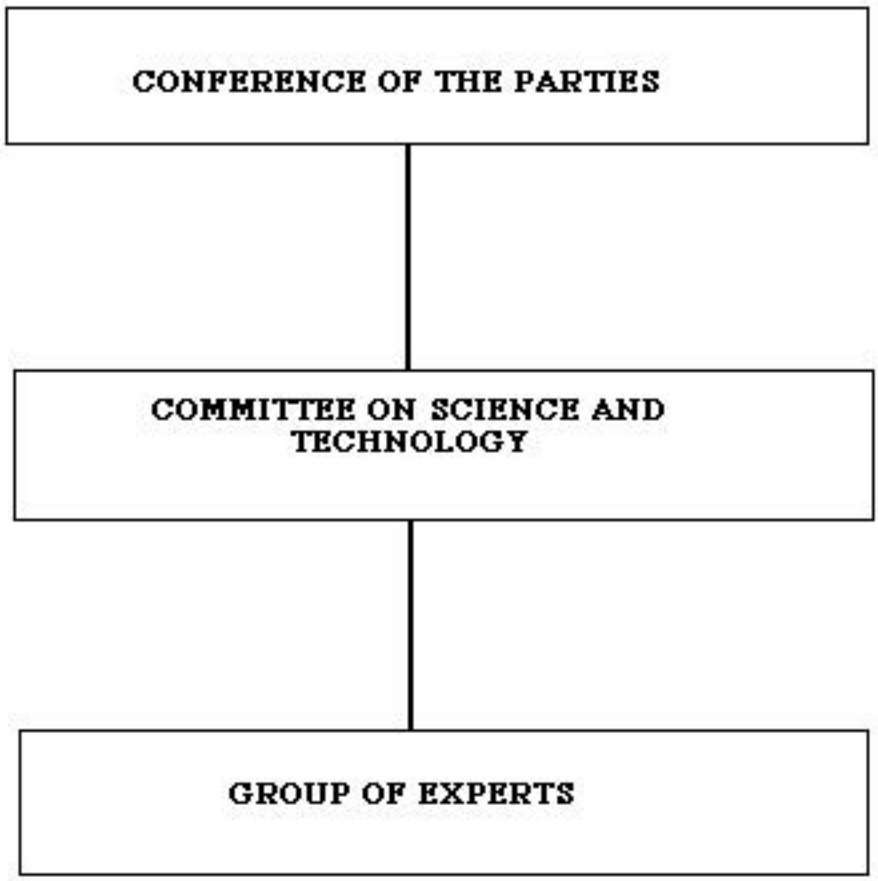
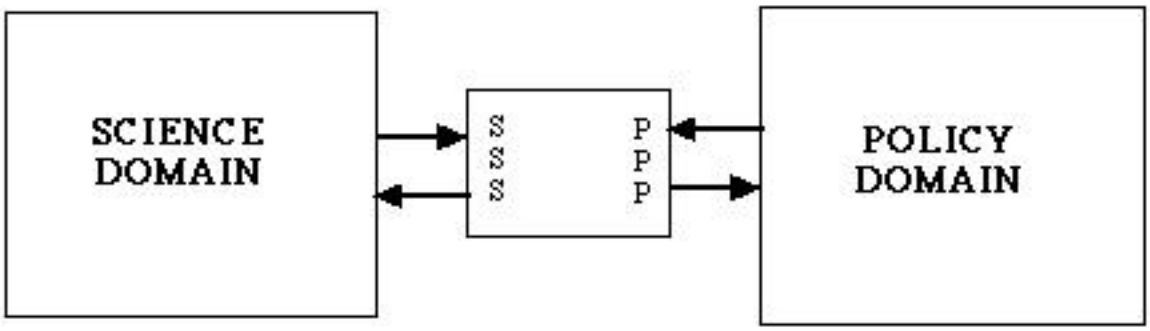
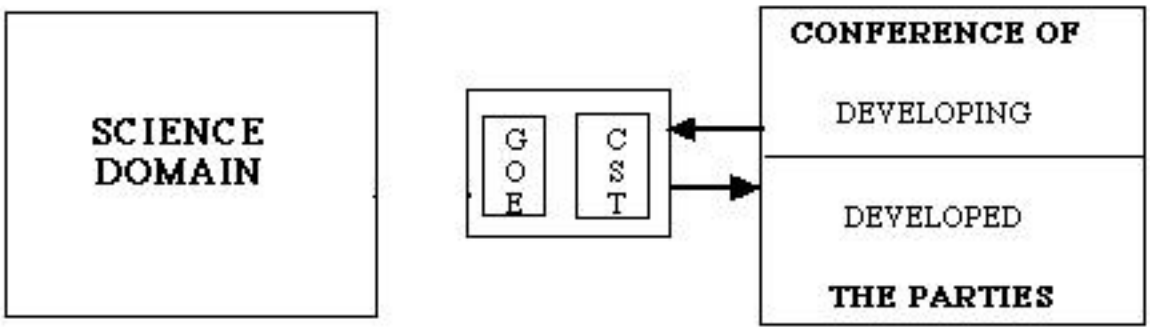

CONFERENCE OF THE PARTIES
COMMITTEE ON SCIENCE AND TECHNOLOGY
GROUP OF EXPERTS

Figure 4. The boundary organization model



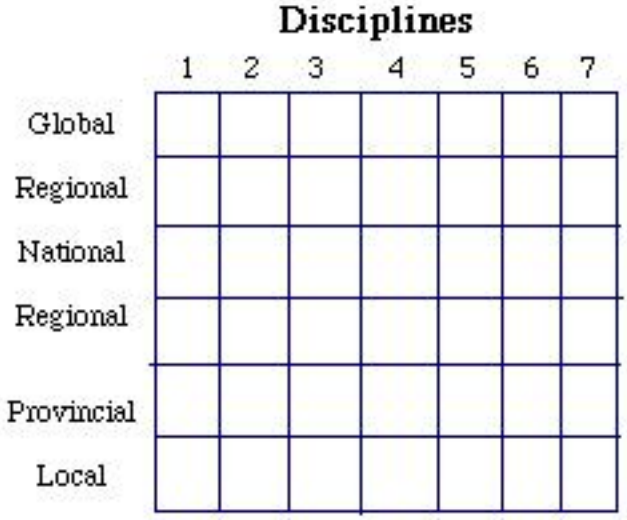
BOUNDARY
ORGANIZATION

Figure 5. The sources of deviations from the ideal boundary organization model in the UN Convention to Combat Desertification



BOUNDARY
ORGANIZATION

Figure 6. The Knowledge-Action Framework of science-policy communication



DISCURSIVE SPACE

INSTITUTIONAL SPACE

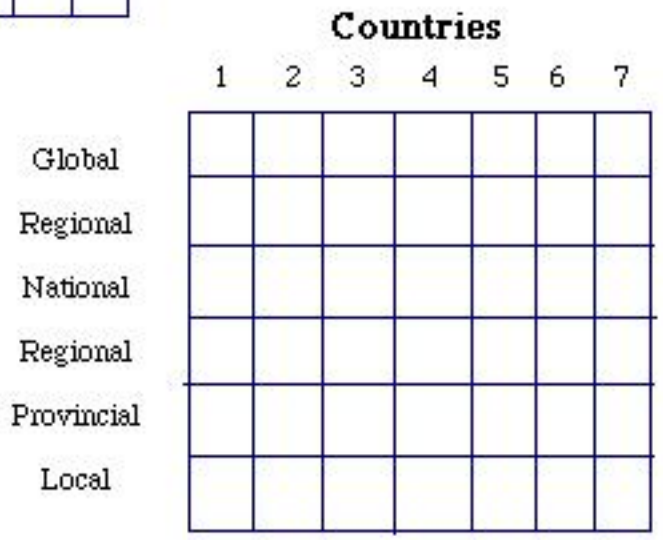
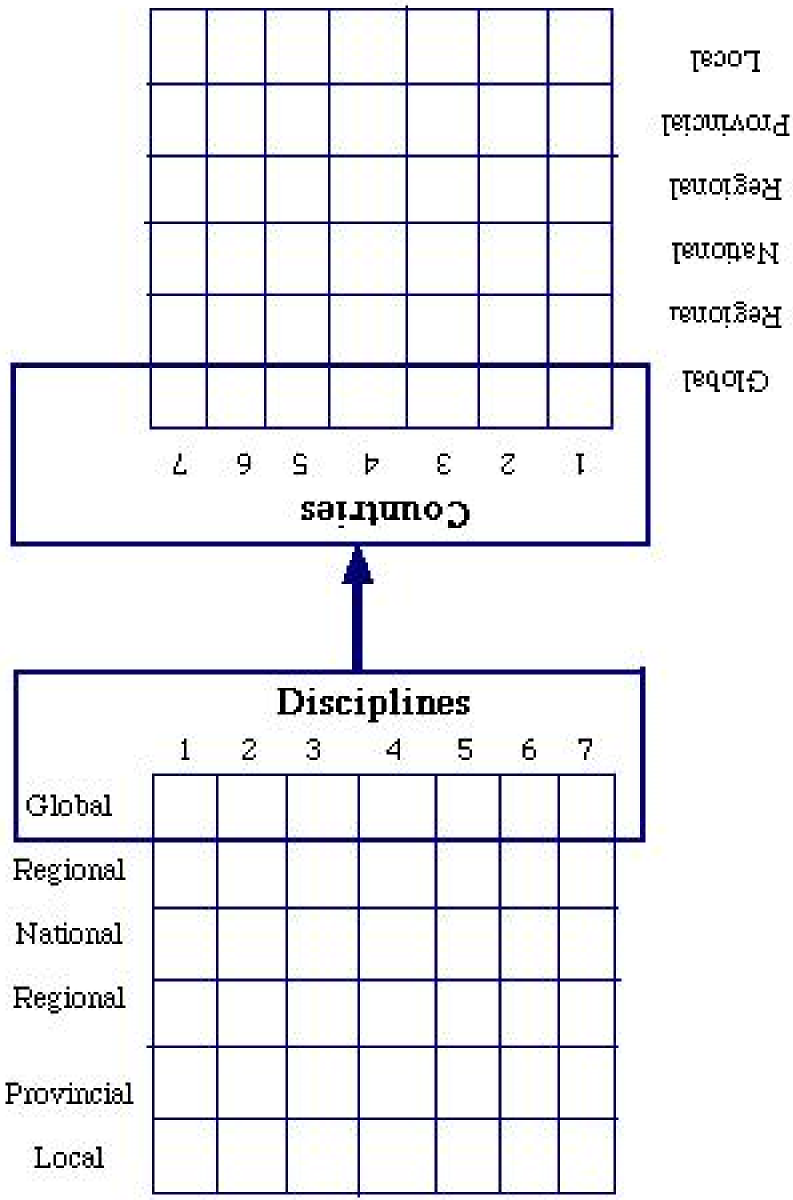


Figure 7. Links between discursive space and institutional space in a typical international environmental regime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Global
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National
Regional
Provincial
Local