



BEIJER

Discussion Papers

Beijer International Institute of Ecological Economics
The Royal Swedish Academy of Sciences

Beijer Discussion Paper Series No. 37

The Interface Between Natural and Social Systems

Fikret Berkes

Box 50005, 104 05 Stockholm, Sweden
Tel: +46-8-673 95 00, Fax: +46-8-15 24 64

2-27-93
WORKSHOP IN POLITICAL THEORY
AND POLICY ANALYSIS
615 NORTH PARK
BLOOMINGTON, INDIANA
BLOOMINGTON, INDIANA 47403-5186
ACPRINT FILES

Beijer Discussion Paper Series No. 37

The Interface Between Natural and
Social Systems

Fikret Berkes

This publication is a part of the Beijer Institute research programme on
"Property Rights and the Performance of Natural Systems", mainly funded
by the John D. and Catherine T. MacArthur Foundation

Beijer International Institute of Ecological Economics, 1993
The Royal Swedish Academy of Sciences
Box 50005, S-104 05 Stockholm, Sweden
Telephone 446(0)8-673 95 00, Telefax +48(0)8-15 24 64
E-mail: BEIJER @ BEIJER.KVA.SE

ISSN 1102-4941

Property Rights and The Performance of Natural Resource Systems
Background Paper prepared for the September 1993 Workshop

The Interface Between Natural and Social Systems

Fikret Berkes

The Beijer International Institute of Ecological Economics
The Royal Swedish Academy of Sciences
Box 50005, S-104 05 Stockholm, Sweden
Telephone: +46-8-673 95 00, Telefax: +46-8-15 24 64
E-mail: beijer@beijer.kva.se

Research Program on Property Rights and the Performance of
Natural Resource Systems

THE INTERFACE BETWEEN NATURAL AND SOCIAL SYSTEMS

Fikret Berkes

University of Manitoba
Natural Resources Institute
Winnipeg, Manitoba R3T 2N2, Canada

Background Paper Prepared for the September 1993 Workshop

The Beijer International Institute of Ecological Economics
The Royal Swedish Academy of Sciences, Stockholm, Sweden

INTRODUCTION

This is a background paper on the focus area, interface between social and natural systems. Following definitions, the paper attempts to present some perspectives on the linkage between social and natural systems, and to cover some aspects of the state of knowledge about how natural resource systems and social systems interact under different property rights regimes, and how that interaction affects the performance of natural resource systems.

The property rights issue of concern in this paper is mainly in the domain of a class of resources which are neither pure private goods or pure public goods. Thus, the scope does not include industries, services, most agricultural land and mineral resources but includes common-property (or common-pool) resources. Further, in the realm of commons, the focus area of this paper is not global commons (Dasgupta and Maler 1992; Keohane et al. 1992), or regional commons, such as the Baltic Basin or the Caribbean Sea, but mostly local commons which is the major literature base on the interface of natural and social systems.

There are four points in the paper. First, we know enough to improve on Hardin's conceptual model of the commons which so dominated the thinking of some scholars and resource managers that it was widely assumed that individuals using resources jointly were helpless to change the incentives they faced. Second, it is argued that the focus on property rights necessarily expands the scope of ecological economics to consider not a two-way linkage (natural systems - economic systems) but a three-way linkage including the social/institutional/cultural dimension. (Elsewhere, we have characterized this linkage as natural capital - cultural capital human-made capital interaction).

Third, the consideration of empirical cases shows that there is no clear-cut verdict on the performance of natural resource systems under different property rights regimes. And this is not for the lack of research and documentation. Fourth, a wealth of evidence suggests that there are no simple property rights solutions. Needed are combinations of property rights regimes and a diversity of property rights institutions that can be adapted for specific circumstances. The paper is offered in the spirit of an overview with some key references, and not as a detailed analysis or synthesis of the subject area. It will be developed further with input from discussions at the September workshop.

DEFINITIONS, PARABLES, REGIMES

Although there is variation in emphasis among scholars, most discussions of common property are concerned with resource types which share two key characteristics: (i) exclusion or control of access of potential users is problematic, and (ii) each user is capable of subtracting from the welfare of all other users. On the basis of these two characteristics, some resources are referred to

as common-property (or common-pool) resources, and defined as a class of resources for which exclusion is difficult and joint use involves subtractability (Berkes 1989, p. 7; Feeny et al. 1990). (For other definitions, see the background paper by Hanna.) This class of resources usually includes fish, wildlife, forests, grazing lands, irrigation and ground water. Most wildlands, parks and public spaces also show characteristics of common-property, most agricultural land and mineral resources do not.

It has been known that resources that share the above characteristics tend to be susceptible to depletion and degradation. This commons dilemma has been referred to as "the tragedy of the commons" (Hardin 1968); it has also been formulated as a Prisoner's Dilemma game or simply as externalities. Costanza (1987), has used the term "social trap" to refer more broadly to any circumstance in which the rational individual choice is inconsistent with the long-term interests of either the individual or society.

For natural scientists, by far the best known of the various formulations of the commons dilemma is the "tragedy of the commons", as used by Hardin as a parable to explain overgrazing in a hypothetical Medieval English commons. Each herdsman seeking individual gain wants to increase the size of his herd. But the commons is finite, and sooner or later the total number of cattle will exceed the carrying capacity of the land. But it is in the rational self-interest of each herdsman to keep adding animals: his personal gain from adding one more animal (+1) outweighs his personal loss (a fraction of -1), from the damage done to the commons. However, since all herdsmen use the same logic, eventually they all lose. Hence, the overexploitation of the commons is an inevitable result, and a tragedy in the sense of ancient Greek tragedies according to Hardin, in which the characters know that the disaster is coming but are unable to do anything about it.

Hardin's (1968, p. 1244) notion that "freedom in the commons brings ruin to all" was taken quite literally, and accorded by some the status of scientific law. But many scholars knew that the case study would not hold up to historical scrutiny and that the generalization about commons was inappropriate (Feeny et al. 1990). Improving upon Hardin's analysis of commons required, among others, an organizing framework of property rights regimes applicable to common property resources (see background paper by McCay).

Briefly, following Ostrom (1990) and Bromley (1992), common-property (common-pool) resources may be held in one of four basic property rights regimes. (1) Open-access is the absence of well-defined property rights. Access is free and open to all. (2) Private property refers to the situation in which an individual or corporation has the right to exclude others and to regulate the use of the resource. (3) State property or state governance means that rights to the resource are vested exclusively in government for controlling access and regulating use; (4) Communal property or common property means that the resource is held by an identifiable

community of users who can exclude others and regulate use. These four regimes are ideal, analytical types. In practice, resources tend to be held in overlapping combinations of these four regimes, and there is variation within each.

On the basis of empirical experience, we can hypothesize that all three property rights regimes, that is, private property, state property and communal property, can under some circumstances, lead to sustainable resource use. By contrast, there is general consensus that open-access is not compatible with sustainability. Hardin's herders, among whom access to the resource is free and rule-making appears not to exist, are functioning in an open-access regime, not communal property. Hardin's confusion of open-access with common-property has been much discussed as a source of confusion in resource management policies as well (McCay and Acheson 1987; Bromley and Cernea 1989; Berkes 1989; Bromley 1992).

The private property solution, advocated by many economists and others, is often not an option because, by definition, there is an exclusion problem with common property resources. As Magrath (1989) put it, many of the resources in question are nonexclusive by nature, and not deemed appropriate for private ownership. This has made common-property resources generally difficult to deal with in conventional economic terms. Ostrom (1986) explains why common-pool resources create problems for the economist:

For a long time, economists classified the world of events — commodity space — into two broad classes; "pure private goods" and "pure public goods". This classification was based on variation along two analytical dimensions: exclusion and jointness of use. Purely private goods can be excluded at relatively low cost from those who did not produce the good. Such goods are consumed individually and not jointly. My consumption of a private good subtracts that particular item completely from your set of options. Pure public goods have the opposite characteristics. Once such a good is produced, it is difficult or costly to exclude others from consumption. Further, my consumption of a pure public good does not subtract from the availability of that good to you. The concepts of "pure private goods" and "pure public goods" group broad classes of phenomena that share the extreme points along two dimensions of exclusion and jointness (Ostrom 1986).

In the case of pure private goods, continues Ostrom (1986), the obvious management regime is private property. In the case of pure public goods, the obvious best match is public sector or the state property regime. But in the case of common-pool resources which are neither pure private goods or pure public goods, the best match is not so easy to determine. The question of the appropriate property rights regime is part of the current policy debate for these vast array of resources with exclusion and jointness problems. It is the recognition of these resources as a distinct category that has given rise to a large body of recent literature that cuts across disciplinary and resource boundaries.

A SYSTEMS VIEW OF THE INTERFACE

Hardin's seminal "tragedy of the commons"¹¹, with its group of Medieval English herders locked in a downward spiral of resource degradation is a powerful metaphor for the consequences of the lack of property rights on the commons. But it is not a very good characterization of what really happens in many commons cases. Much of the commons literature suggests instead a "bucket brigade" metaphor. Given a resource management problem, a group of people will often organize themselves in a way that is similar to the formation of a bucket brigade to put out the fire in a rural community.

Figure 1 attempts to summarize the two metaphors as simple feedback models of an integrated natural-social system. The major differences between the two models are in the stabilizing feedback loops that connect the social system and the natural system. For common property resource use to be sustainable, there should be, feedback informing the management institution about the state of the resource; there should also be feedback between the regime and the resource user. When these stabilizing feedbacks are absent (or assumed away, as done by Hardin) then one is left with a runaway positive feedback loop, and this integrated social-natural system cannot be sustainable in the long-term.

Such an interpretation is consistent with the literature. A surge of interest in property rights issues in natural resources, especially in the last five to ten years, has resulted in a considerable accumulation of empirical and some theoretical studies. Much of this common property literature is notable in its attempt to study the interface between natural and social systems, and to establish a dialogue between natural resource specialists and social science specialists. Some of this literature is captured and interpreted in a series of fairly recent volumes by National Research Council (1986), McCay and Acheson (1987), Ostrom et al. (1988), Wade (1988), Berkes (1989), Bromley and Cernea (1989), Magrath (1989), Ostrom (1990), Chopra et al. (1990), Baxter and Hogg (1990), Stevenson (1991), Ostrom (1992), Tang (1992), Jodha (1992), and Bromley (1992).

The volumes mentioned above account for only a fraction of the writings on this subject. The common property bibliography prepared by Fenton Martin at Indiana University has seven thousand entries. At the four annual conferences of IASCP, the International Society for the Study of Common Property (held in 1990 at Duke University, 1991 Winnipeg, 1992 Washington DC and 1993 Manila), nearly 400 papers were delivered.

Some of the major lessons from the common property literature that I wish to highlight in regard to the interface between natural and social systems, may be summarized as follows:

- resource users are often not a collection of independent individuals but tend to be connected through formal or informal institutions, and they are capable of communication and altering incentive structures,
- from a historical perspective, the use of common-property resources has rarely been a free-for-all, except for short periods of rapid change,
- there often is a resource management regime, which may be a government regime but more often a local, informal regime, that regulates the way in which resources are used,
- in the case of local, informal regimes, the resource use behaviour of individuals is often mediated by a variety of social controls or social sanctions,
- the presence of a "community" is an important (Taylor 1982; Singleton and Taylor 1992) but not a sufficient condition to solve the commons problem (Ostrom 1992),
- many of the principles that may be derived from local commons cases are applicable to, or have their parallels with international commons cases (Keohane et al. 1992),
- there are design principles (Ostrom 1990; 1992 identifies eight) which may be used as predictors of success for common property institutions, and
- there often are numerous feedback loops in most natural-social systems involved in the use of common property, as partially sketched in Fig. 1.

Returning to Hardin's Medieval commons case, it is certainly possible that in the long history of Medieval English commons, the grazing system may have become open-access at certain times and places. But that could not have been the norm. Given that open-access systems could not have persisted except when resources were super-abundant, open-access is an historically transient phenomenon and an evolutionary dead-end. Yet, paradoxically, open-access has its uses also: it is an efficient regime for the quick conversion of resources into money.

Thus, it is not surprising that colonialists often dismantled communal property regimes and institutions as a prelude to establishing colonial economies (e.g., Gadgil and Guha 1992; Ruddle, in press). Likewise, the Western principle of the Freedom of the Seas is also consistent with an economy in which resources are treated like a business in liquidation, as some ecological economists have put it. What, then, are the barriers to liquidation? It follows that in a research program on property rights and natural resource systems, some of the more promising lines of inquiry are likely to involve the study of feedbacks, such as those in common property institutions.

ANOTHER VIEW OF THE INTERFACE

A two-way interaction between society and natural resources may not be sufficient to provide a sense of the complexity of interactions. Consider the case of James Bay Cree Indian hunting territory system in James Bay, subarctic Canada. Berkes (1989) proposed a model of changes in the territory system over time (Fig. 2). Consistent with ethnohistorical evidence, the land tenure system prior to the development of the fur trade in the 18th century, probably involved communal territories, with groups of families sharing traditional areas which were not clearly demarcated. Intensification of resource use (mainly beaver) due to development of the fur trade and perhaps population growth, appears to have led to a system with family-controlled territories.

The system could revert back to a looser, communal arrangement if resource use became less intensive. It could also degenerate into an open-access system if local common-property institutions were destroyed. Competition among fur companies and incursion into the area of outsiders seem to have done exactly that on as many as three occasions over three centuries, with the last event occurring in 1920-30, all followed by recovery of both the common-property institution and the resource (Berkes 1989).

Such a view of the natural system-social system interface requires a more elaborate model than that provided by Fig. 1, one that is capable of taking into account additional factors. Emerging concepts in the field of ecological economics suggest a model with three-way interactions (Fig. 3), rather than two-way.

In general terms, property rights institutions are part of the "cultural capital" by which societies convert "natural capital", that is, resources and ecological services, into "human-made capital" or the produced means of production. The following discussion borrows heavily from Berkes and Folke (in press). We have used the term cultural capital to refer to factors that provide human societies with the means and adaptations to deal with the natural environment and to actively modify it. As we see it, cultural capital includes what others have called social capital and institutional capital. It also includes how people view the natural world, values and ethics, including religion, and culturally transmitted knowledge of the environment, indigenous knowledge.

Figure 3 presents a view of how the three kinds of capital may be interrelated. Natural capital is the basis for cultural capital. For example, property rights institutions are closely related to the characteristics of the resources used by that society (Geertz 1963). In turn, attitudes and practices of a society regulates the exploitation of its natural capital (Freeman et al. 1991; Posey and Balee 1989). Thus, human-made capital is generated jointly by natural and cultural capital? the use of natural capital under a particular set of institutions, attitudes and technology produces

human-made capital. Human-made capital may, in turn, alter cultural capital; for example, technologies may mask a society's dependence on natural capital and provide a false sense of control over nature. Thus, cultural capital is closely linked to how natural capital will be used; technologies reflect cultural values, world view and institutions (Gadgil et al. 1993; Warren et al. 1993).

Within a framework of three-way interactions, how would the three capitals interact under different property rights regimes? The short answer is that we do not know. There is no well developed literature in this area, as ecological economists have been largely concerned with the interaction of natural capital and human-made capital. Human capital and especially the question of property rights institutions have received little attention from ecological economists. However, some tentative observations/speculations may be offered:

- ways of enhancing the turnover of information within the larger system will enhance the performance of the natural system,
- new adaptations or a constant elaboration of cultural capital will be necessary to keep up with changes in human-made capital,
- the sustainable use of natural capital will be facilitated by those property rights regimes capable of responding to feedbacks from natural capital, and
- property rights regimes must be flexible (rather than "brittle"), diverse and capable of self-renewal, in the spirit of Holling (1986).

The introduction of the notion of cultural capital, with all the informal and intangible dimensions that it embodies, no doubt complicates the more manageable ecology-economics dichotomy. But it also serves to highlight systems many of which are informal and thus largely "invisible" to conventional analyses. These informal systems (such as local common-property institutions and traditional knowledge-systems) tend to be found more in the Third World than the Industrial West, more in rural than in urban areas, and in many cases, more in female-dominated than in male-dominated activities. These are not areas in which conventional analyses are known to be strong.

PERFORMANCE OF NATURAL RESOURCE SYSTEMS

The question of the performance of natural resource systems under different property rights regimes begs the question of criteria. How can the "success" of natural resource use cases be assessed? In his widely used common-property analysis framework, Oakerson (1986; 1992) suggested two criteria, efficiency (defined as Pareto optimality) and **equity**. These criteria have been applied to a large number of case studies reported in the two books, National Research Council (1986) and Bromley (1992).

Alternative criteria include **empowerment** and **livelihood protection** as proposed by some development specialists (ICLARM 1993). Feeny et al. (1990) sought a criterion which is both human-centric and resource-centric, and not exclusively one or the other, and used **ecological** sustainability as the measure of success for common property management. That is, they focused on whether the resource in question was used sustainably in the sense of the Brundtland Commission, "without compromising the ability of future generations to meet their own needs" (WCED 1987).

Using the criterion of sustainability, Feeny et al. (1990) evaluated the success of the four pure property rights regimes against the challenges posed by the two characteristics of common property resources, exclusion and subtractability. The evidence on exclusion showed that there were enforcement problems with all types of property rights, including private property. State property regimes probably fared the worst in terms of enforcement problems. Communal property regimes did not work well under stress from colonialism, population pressure, technological change and economic change (e.g. Jodha 1985; 1992). Nevertheless, successful exclusion was found with grazing lands, forests and water resources (Netting 1981; Dani et al. 1987; Baxter and Hogg 1990; Fortmann and Bruce 1988; Wade 1988).

The evidence on subtractability, that is, the success of different property rights regimes in regulating use and users, was also mixed. Some cases of open-access, where the resource was abundant and the user's time scarce (e.g. bison in the US West in early 1800s), may have been economically rational but not sustainable in the long run. Under private property, sustainable use was feasible in many cases, but may not have been economically rational for resources which renew themselves very slowly, e.g. whales (Clark 1973). Under communal property, success depended on the ability of users to forge appropriate institutions, which in turn depended on a number of factors (Ostrom 1990). There was a large literature on the diversity of such institutions, starting with Scott (1955) who is usually credited with the first statement of the theory of the commons, and who pointed out the existence of traditional use-rules such as stinting which limited the number of cattle on the Medieval English commons.

The review concluded that solutions to both exclusion and subtractability problems were feasible under each of private, state and communal-property regimes. However, no single property rights regime was sufficient to guarantee the sustainable use of resources (Feeny et al. 1990). Other authors have used various criteria to evaluate common property institutions and economic performance (rather than the natural resource system itself).

These include Blomquist (1992) on Southern California groundwater (also summarized in Ostrom 1990), and Tang (1992) on a number of irrigation case studies. Chopra et al. (1990) and Chopra and Kadakodi (1991) analysed the performance of participatory institutions in the management of common and private property

resources in Northwestern India village communities. Stevenson (1991) examined the economic performance of private and communal property rights systems in Swiss alpine meadows. He found that in the more productive lower elevations, private property was more efficient. In the less productive higher elevations, remote areas unsuitable for private property because of higher management costs, communal property performed as efficiently as private property.

In contrast to these detailed studies of institutions and economic performance, there seem to be no detailed studies or syntheses that focus on the performance of the natural resource itself under different property rights regimes. What is available, however, is a rich literature on local and traditional management systems. Perhaps the most striking feature of the case studies in the literature is the sheer diversity of property rights institutions, especially in the older, historically rooted resource management systems. For example, there is a diverse array of arrangements from island group to island group in the reef and lagoon tenure systems of Oceania (Ruddle and Akimichi 1984; Ruddle, in press). Johannes (1978) found that "almost every basic fisheries conservation measure devised in the West as in use in the tropical Pacific centuries ago".

Compared to this diversity of conservation measures and common-property arrangements, resource management prescriptions of the West which have been replacing the traditional systems are rather bland and uniform in nature. Gadgil and Berkes (1991) and McNeely (1991), among others, have pointed out that scientific management has its roots in the utilitarian and exploitive world view that assumes that humans have dominion over nature, and is best geared for the efficient utilization of resources as if they were limitless. The replacement of a diversity of local systems by a monolithic scientific management vision, has in most cases not led to sustainable outcomes. There are many examples of natural resource depletion or degradation due to the replacement of locally adapted, subtle and complex common-property systems, by government management or private property, especially in the Third World (McCay and Acheson 1987; Berkes 1989; Baxter and Hogg 1990).

The conventional resource management science, best geared for exploitive development ("business in liquidation") but not for sustainable use, is in need of fundamental rethinking. The range of changes include those regarding world views and, more pertinent to the present subject, property rights and institutional arrangements. The task is to make institutional arrangements more diverse, not less? natural system-social system interactions more responsive to feedbacks; management systems more flexible and accommodating of environmental perturbations and thus less "brittle".

REFERENCES

- Baxter, P.T.W. and Hogg, R., editors. 1990. Property, Poverty and People: Creating Rights in Property and Problems of Pastoral Development. Department of Social Anthropology and International Development Centre, University of Manchester, Manchester.
- Berkes, F., editor 1989. Common Property Resources. Ecology and Community-Based Sustainable Development. Belhaven, London.
- Berkes, F. and Folke, C., in press. Investing in cultural capital for the sustainable use of natural capital. In: Investing in Natural Capital: An Ecological Economic Approach to Sustainability, A.M. Jansson et al., editors.
- Blomquist, W. 1992. Dividing the Waters. Governing Groundwater in Southern California. Institute for Contemporary Studies Press, San Francisco.
- Bromley, D.W., editor 1992. Making the Commons Work. Theory, Practice and Policy. Institute for Contemporary Studies Press, San Francisco..
- Bromley, D.W. and Cernea, M.M. 1989. The management of common property natural resources. World Bank Discussion Paper No. 57.
- Chopra, K. and Kadekodi, G.K. 1991. Participatory institutions: The context of common and private property resources. Environmental and Resource Economics 1: 353-372.
- Chopra, K, Kadekodi, G.K. and Murty, M.N. 1990. Participatory Development, People and Common Property Resources. Sage, New Delhi.
- Clark, C.W. 1973. The economics of overexploitation. Science 181: 630-634.
- Costanza, R. 1987. Social traps and environmental policy. BioScience 37:407-412.
- Dani, A.A., Gibbs, C.J.N. and Bromley, D.W. 1987. Institutional Development for Local Management of Rural Resources. East-West Center, Honolulu.
- Dasgupta, P. and Mäler, K.-G. 1992. The Economics of Transnational Commons. Clarendon, Oxford.
- Feeny, D., Berkes, F., McCay, B.J. and Acheson, J.M. 1990. The tragedy of the commons: Twenty-two years later. Human Ecology 18: 1-19.
- Fortmann, L. and Bruce, J.W., editors 1988. Whose Trees? Proprietary Dimensions of Forestry. Westview, Boulder.

Freeman, M.M.R., Matsuda, Y. and Ruddle, K., editors 1991. Adaptive Marine Resource Management Systems in the Pacific. Special issue of Resource Management and Optimization, Vol. 8, No. 3/4.

Gadgil, M. and Berkes, F. 1991. Traditional resource management systems. Resource Management and Optimization 8: 127-141.

Gadgil, M., Berkes, F. and Folke, C. 1993. Indigenous knowledge for biodiversity conservation. *Ambio* 22: 151-156.

Gadgil, M. and Guha, R. 1992. *This Fissured Land: An Ecological History of India*. Oxford University Press, New Delhi.

Geertz, C. 1963. *Agricultural Involution*. University of California Press, Berkeley.

Hardin, G. 1968. The tragedy of the commons. *Science* 162: 1243-1248.

Holling, C.S. 1986. The resilience of terrestrial ecosystems: Local surprise and global change. In: *Sustainable Development of the Biosphere*. Clarke, W.C. and Munn, R.E., editors. Cambridge University Press, Cambridge, pp. 292-317.

ICLARM 1993. *Workshop on Community Management and Common Property of Coastal Fisheries in Asia and the Pacific*. International Center for Living Aquatic Resources Management/International Institute of Rural Reconstruction, Silang, Philippines.

Jodha, N.S. 1985. Population growth and the decline of common property resources in Rajasthan, India. *Population and Development Review* 11: 247-264.

Jodha, N.S. 1992. Common property resources. A missing dimension of development strategies. World Bank Discussion Paper No. 169.

Johannes, R.E. 1978. Traditional marine conservation methods in Oceania and their demise. *Annual Review of Ecology and Systematics* 9: 349-364.

Keohane, R., McGinnis, M. and Ostrom, E. 1992. *Proceedings of a Conference on Linking Local and Global Commons*, held at Harvard University, April 1992, Cambridge.

Magrath, W. 1989. *The challenge of the commons*. World Bank, Environment Department Working Paper No. 14.

McCay, B.J. and Acheson, J.M., editors 1987. *The Question of the Commons. The Culture and Ecology of Communal Resources*. University of Arizona Press, Tucson.

McNeely, J.A. 1991. Common property resource management or government ownership: Improving the conservation of biological resources. *International Relations* 1991: 211-225.

National Research Council 1986. Proceedings of the Conference on Common Property Resource Management. National Academy Press, Washington, D.C.

Netting, R. McC. 1981. Balancing on an Alp. Cambridge University Press, Cambridge.

Oakerson, R.J. 1986. A model for the analysis of common property problems. In: National Research Council, Proceedings of the Conference on Common Property Resources Management. National Academy Press, Washington, D.C. (Also in Bromley 1992).

Ostrom, E. 1986. Issues of definition and theory: Some conclusions and hypotheses. National Research Council, Proceedings of the Conference on Common Property Resources Management. National Academy Press, Washington, D.C.

Ostrom, E. 1990. Governing the Commons. The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge.

Ostrom, E. 1992. Community and the endogamous solution of commons problems. Journal of Theoretical Politics 4: 343-351.

Ostrom, E. 1992. Crafting Institutions for Self-Governing Irrigation Systems. Institute for Contemporary Studies Press, San Francisco.

Ostrom, V., Feeny, D. and Picht, H., editors 1988. Rethinking Institutional Analysis and Development. Institute for Contemporary Studies Press, San Francisco.

Posey, D.A. and Balee, W., editors 1989. Resource Management in Amazonia: Indigenous and Folk Strategies. Special issue of Advances in Economic Botany, Vol. 7.

Ruddle, K. and Akiraichi, T., editors. 1984. Maritime Institutions in the Western Pacific. Senri Ethnological Studies, 17. National Museum of Ethnology, Osaka.

Ruddle, K., in press. Traditional Community-Based Marine Resource Management Systems in the Asia-Pacific Region: Status and Potential. ICLARM Contribution No. 931.

Scott, A.D. 1955. The fishery: The objectives of sole ownership. Journal of Political Economy 63: 116-124.

Singleton, S. and Taylor, M. 1992. Common property, collective action and community. Journal of Theoretical Politics 4: 309-324.

Stevenson, G.G. 1991. Common Property Economics. A General Theory and Land Use Applications. Cambridge University Press, Cambridge.

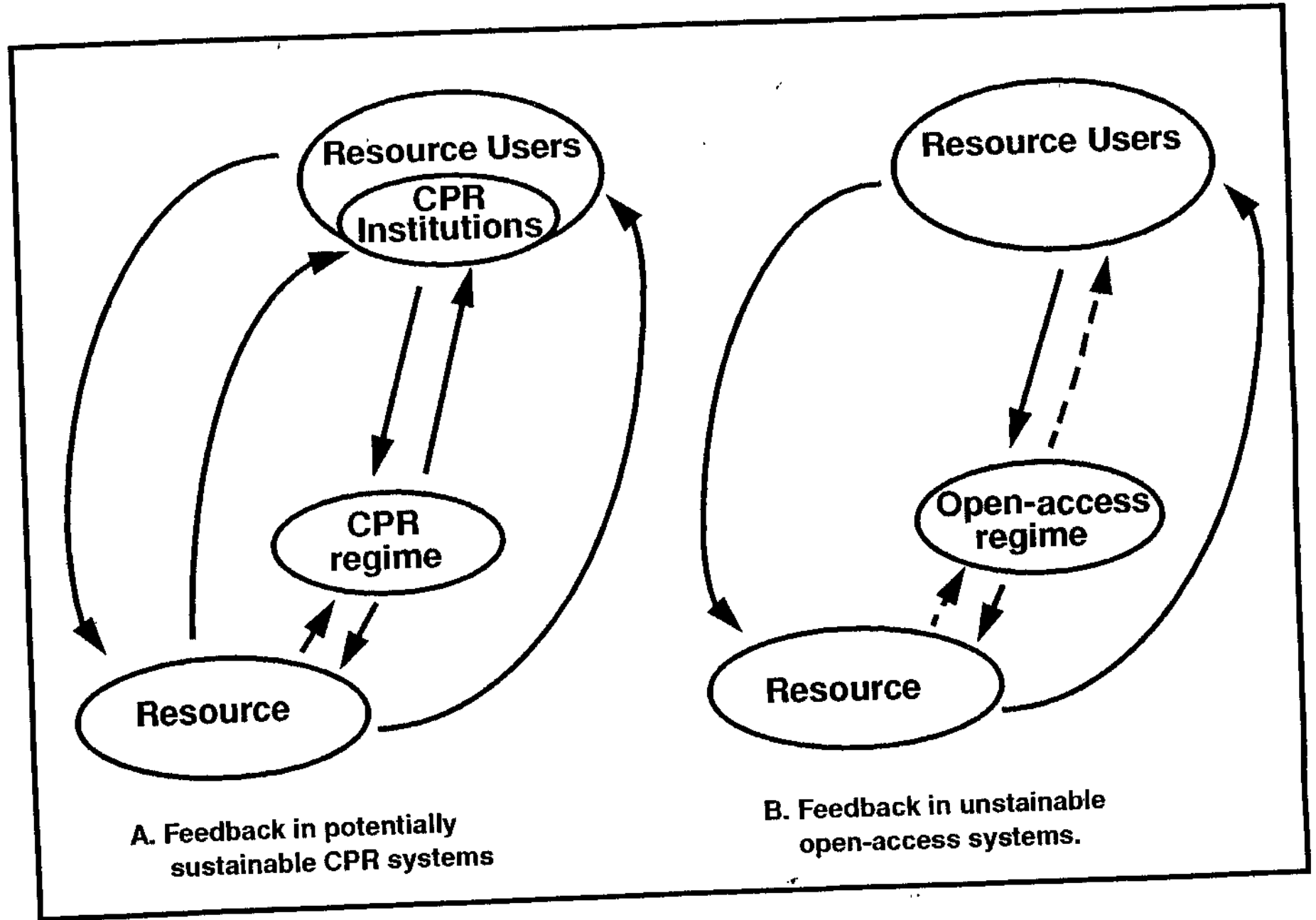
Tang, S.Y. 1992. Institutions and Collective Action: Self-Governance in Irrigation. Institute for Contemporary Studies Press, San Francisco.

Taylor, M. 1982. Community, Anarchy, and Liberty. Cambridge University Press, New York.

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

Wade, R. 1988. Village Republics: Economic Conditions for Collective Action in South India. Cambridge University Press, Cambridge.

Warren, D.M., Brokensha, D. and Slikkerveer, L.J., editors 1993. Indigenous Knowledge Systems. The Cultural Dimension of Development. Kegan Paul International, London.



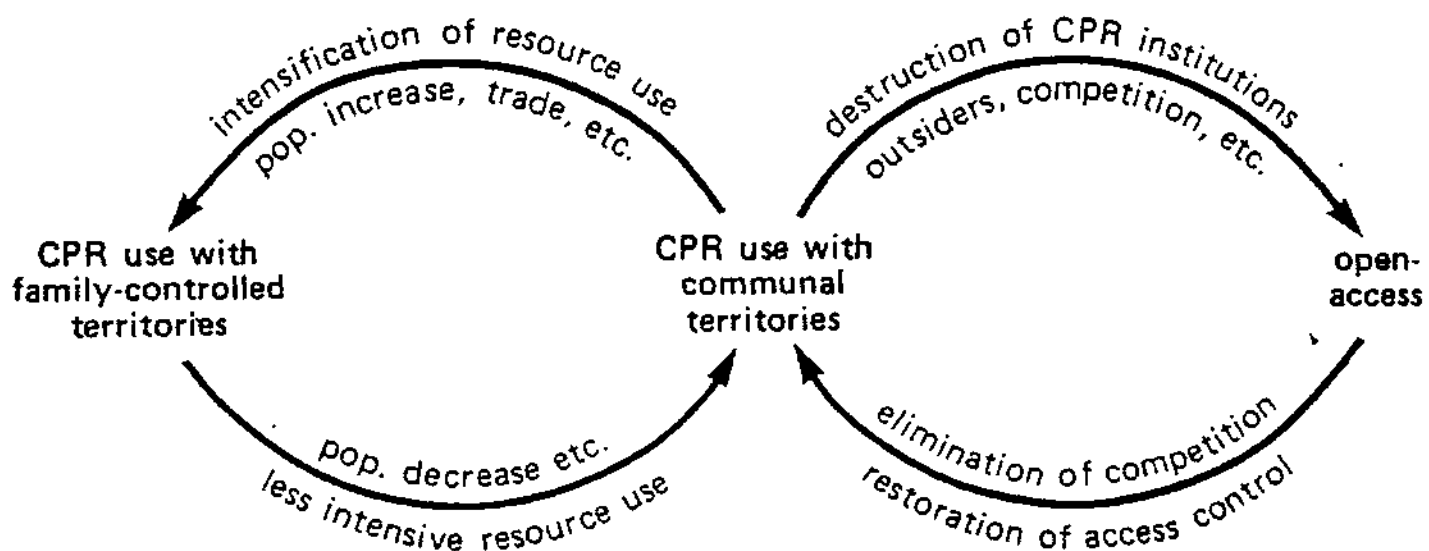


Figure 2 Relationship between common-property resource (CPR) use and the development of common-property institutions and conservation practices: a systems view.

Source: Berkes, "Cooperation from the perspective of human ecology",
 In: Common Property Resources, Belhaven, London.

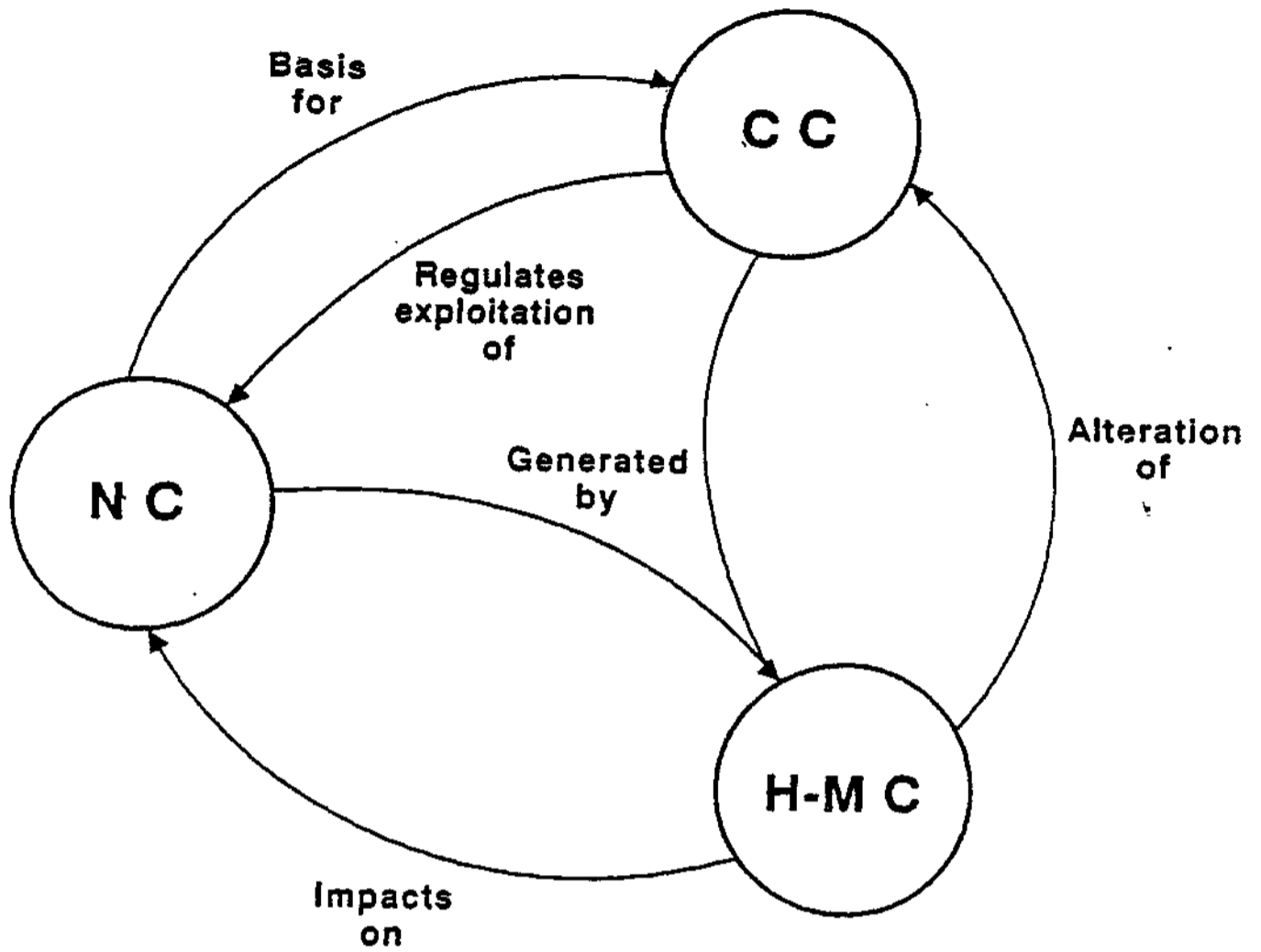


Figure 3. First-order interrelationships among natural capital (NC), human-made capital (H-MC) and cultural capital (CC).

Beijer Discussion Papers 1991-1994
February 1994

1. **The Ecology and Economics of Biodiversity Conservation:
Elements of a Research Agenda**
Charles Penings, Carl Folke and Karl-Goran Maler. 1991.
2. **Towards an Ecological Economics of Sustainability**
Mich Common and Charles Penings. 1992
3. **Aspects Stratégiques des Négotiations Internationales sur les
Pollutions Transfrontières et du Partage des Coûts de l'Épuration**
Parkash Chander and Henry Tulkens. 1992.
4. **Multiple Use of Environmental Resources: The Household-
Production-Function Approach**
Karl-Göran Måler. 1992.
5. **Nested Living Systems**
Folke Günther and Carl Folke. 1992
6. **The Tragedy of the Commons and the Theory of Social Overhead
Capital**
Hirofumi Uzawa. 1992.
7. **Harvesting Semelparous Populations and Variability in the Life
History of Salmon**
Veijo Kaitala and Wayne M. Getz. 1992.
8. **Cultural Capital and Natural Capital Interrelations**
Carl Folke and Fikret Berkes. 1992
9. **Imputed Prices of Greenhouse Gases and Land Forests**
Hirofumi Uzawa. 1992
10. **Regulating the Farmers' Use of Pesticides in Sweden**
Ing-Marie Andréasson-Gren. 1992
11. **The Population Problem**
Partha Dasgupta. 1992
12. **An Ecological Economy:
Notes on Harvest and Growth**
Gardner Brown and Jonathan Roughgarden. 1992
13. **Towards a General Theory of Social
Overhead Capital**
Hirofumi Uzawa. 1992
14. **Benefits from Restoring Wetlands for Nitrogen
Abatement: A Case Study of Gotland**
Ing-Marie Gren. 1992
15. **Trade, Tropical Deforestation and Policy Interventions**
Edward B. Barbier and Michael Rauscher. 1992
16. **Foreign Trade and Renewable Resources**
Michael Rauscher. 1992

17. **Sensitivity of Willingness-to-Pay Estimates to Bid Design in Dichotomous Choice Contingent Valuation Models: A Comment**
Barbara J. Kanninen and Bengt Kriström. 1992
18. **Debt-for-Environment Swaps: The Institutional Dimension**
Tomasz Zylicz. 1992
19. **Modeling Complex Ecological Economic Systems: Toward an Evolutionary, Dynamic Understanding of Humans and Nature**
Robert Costanza, Lisa Wainger, Carl Folke and Karl-Göran Mäler. 1992
20. **Welfare Benefit Estimation and the Income Distribution**
Barbara J. Kanninen and Bengt Kriström. 1992
21. **Internalizing Environmental Costs of Salmon Farming**
Carl Folke, Nils Kautsky and Max Troell. 1992
22. **Resource leasing and optimal periodic capital investments**
Andy Nowak, Veijo Kaitala and Gustav Feichtinger. 1993
23. **Improving Environment through Permit Trading: The Limits to Market Approach**
Tomasz Zylicz. 1993
24. **Cost-Effectiveness of the Baltic Sea Clean-Up: Will Wetlands Reconcile Efficiency with Biodiversity?**
Tomasz Zylicz, Ing-Marie Gren. 1993
25. **Economic Growth and the Environment**
Karl-Göran Mäler. 1993
26. **Environmental Impact of Government Policies and External Shocks in Botswana, Lena Unemo. 1993**
27. **Poverty, Institutions, and the Environmental-Resource Base**
Partha Dasgupta and Karl-Göran Mäler. 1993
28. **The acid rain game as a resource allocation process with an application to the international cooperation among Finland, Russia, and Estonia**
Veijo Kaitala, Karl-Göran Mäler, and Henry Tulkens. 1993
29. **Ecological limitations and appropriation of ecosystem support by shrimp farming in Columbia, Jonas Larsson, Carl Folke and Nils Kautsky. 1993**
30. **Wetland Valuation: Three Case Studies**
R.K. Turner, C.Folke, I-M. Gren and I J. Bateman. 1993
31. **Traditional Ecological Knowledge, Biodiversity, Resilience and Sustainability**
Fikret Berkes, Carl Folke and Madhav Gadgil. 1993
32. **The Acid game II**
Karl-Göran Mäler, 1993
33. **Investing in Natural Capital: Why, What, and How?**
Carl Folke, Monica Hammer, Robert Costanza and AnnMari Jansson, 1993
34. **The Economic Management of High Seas Fishery Resources: Some Game Theoretic Aspects**
Veijo Kaitala and Gordon Munro, 1993

35. **Discontinuous Change in Multilevel Hierarchical Systems**
J. Barkley Rosser, Jr., Carl Folke, Folke Günther, Heikki Isomäki,
Charles Perrings, Garry Peterson and Tõnu Puu. 1993
36. Comparing Ecological **and** Social Systems
C.S. Holling, Lance Gunderson and Garry Peterson, 1993