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A PERSPECTIVE AT THE SÁMI-NORWEGIAN CASE OF CO-MANAGEMENT IN THE REINDEER INDUSTRY- Regional Failure and Success at the End of the Old Millenium

Abstract

The Sámi is recognized as the indigenous people of Northern and Middle Fennoscandia and the Kola Peninsula. The reindeer has been an important source of living since prehistoric times, and currently the reindeer industry is still an important for the sustenance of Sámi culture and identity. It has a mixed management regime where the pasture resource regulated by common property produces inputs to the production functions of individual owners. Through the old Millenium Sapmi (Sámiland) have been gradually been colonized by the nation-states of the current Norway, Sweden, Finland and Russia and finally incorporated with the state borders established in the 18th and the 19th centuries.

The experiences from the Sámi -Norwegian case should be viewed in some perspective. In 1976 the Norwegian government and the Association of Norwegian Reindeer Herding Sámi (NRL) signed a Main Agreement for the Reindeer Industry establishing the basis for a new co-management system which still is at work parallel with regulation by law. The intentions included promoting good resource utilization and sustaining the industry as a part of Sámi culture. What is striking, is the variation in the achievements of the Sámi-Norwegian system. To a considerable extent the outcome follows a regional pattern. During the 1980's the southernmost regions experienced an prosperity without overgrazing, while the northernmost regions encountered both low income and an increasing overgrazing of vulnerable lichen pastures due to a 150 % growth in animal numbers (Riseth and Vatn, 1998). The well-intended scheme seems to have been successful for not much more than a decade and only for a part of the Norwegian segment of Sapmi. The paper will analyze possible reasons for this by means of IAD Framework and models developed a recent Ph. D dissertation, (Riseth, 2000). The explanations suggested include differences in nature geography, culture and historical inter-ethnic relations. As a conclusion the most important factors seem to have been the physical features of the pastures, and the society's capacity for increasing its institutional capacity. The natural conditions for adapting to the technological change seem to have been more in favor of stabilizing strategies in the South. Further the South Sámi were also better prepared than their fellows in the North.

1 Introduction

The Sámi people, once autonomous, are currently an ethnic minority in four nation states. The Sámi is, however, officially recognized as the indigenous people of Northern Fennoscandia. Throughout the recently ended Millenium Sapmi has gradually been colonized by the nation-states of the current Norway, Sweden, Finland and Russia and finally incorporated within the state borders established in the 18th and the 19th centuries. During the same couple of centuries, there were several waves of settlement expansion into Sámi areas. In the last part of the nineteenth century, a new ideology (social Darwinism) achieved supremacy in the then twin kingdoms of Norway-Sweden. Sámi reindeer herd management was considered *inferior* to the majority peoples' expanding agriculture. Legislation from the last decades of the 19th century and the first decades of the 20th century had clear objectives of limiting the extent and rights of reindeer management. The offensive against reindeer management was a part of a general offensive towards Sámi culture and language. It lasted down to the post-war era. In Norway the Act of Reindeer Herd Management of 1933, in force until 1979, was based upon a governmental attitude considering pastoralism as *a dying way of life.* It should be allowed to exist until vanishing, the presumption being that it would give way in conflict with agriculture.

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However, reindeer pastoralism proved vital in spite of both negative governmental attitudes and resource pressure from agriculture. Moreover the herders life started to change, particularly after the Second World War, and more rapidly from the 1960's on. Modernization also reached the mountains of Sapmi. Important, and interconnected, processes were (1) a gradual sedentarization, (2) a change from being a universal way of life towards becoming a mere occupation and (3) a growing motorization of the daily work operations. This was followed with more general societal processes as (4) extension of external markets for reindeer products, production inputs and consumption goods, and (5) integration into the Nordic welfare societies with obligatory schooling, social welfare, industry subsidies and public labor markets. Among these processes the *technological change* from full dependence of animal and human muscle to an increasingly higher dependence on motorized vehicles as snowmobiles, cars, and all terrain vehicles (ATVs) seems to have had a particular *triggering effect speeding other economic and societal processes* in the herding society. We may speak of a *technological revolution* in herder societies. This revolution started with the introduction of — and rapid switch to — the snowmobile and was widespread in the circumpolar North, having extensive impacts on as well Sámi as Inuit societies (Moran, 1979:132, cf. Pelto, 1973:151). However, the revolution followed different courses in different countries and regions.

Within Norway changes in governmental attitudes in the Postwar Era brought forward minor efforts providing support to reindeer management and Sámi culture in a broader sense. The changes in Norwegian public policy had become considerable at the end of the 1970's. The regulations intended for passive liquidation of reindeer pastoralism were gradually abolished. An extensive co-management reform evolved, partly in the 1960's but mainly during the 1970's, and implemented mainly during the 1980's. The reform had two core elements; (1) a main agreement for the industry (Landbruksdepartementet, 1976a), and (2) a new regulation act. The agreement was a result of negotiations and signed by the Ministry of Agriculture and the Association of Norwegian Reindeer Herding Sámi (NRL) in 1976 and approved by Stortinget (the parliament). Stortinget approved the act after public inquiry. The aims of the institutional reform included: (1) sustainable resource use, (2) safe income and living conditions for the herders, (3) ensuring herders' property rights, and (4) maintaining reindeer management as a part of the Sámi culture (Landbruksdepartementet, 1976b, Norges Lover, 1978).

The Act of Reindeer Management (Lov om reindrift) specifies property rights and a governance system with boards on several levels (Norges Lover, 1978). Administratively the area with recognized usufruct rights is divided into six Reindeer Pasture Areas, cf. Figure 1. Sámi reindeer management has usufruct rights over about 40 % of the Norwegian land surface, covering most of the four northernmost counties (Finnmark, Troms, Nordland, and North Trøndelag) and parts of two more (South Trøndelag and Hedmark). Contemporary Sámi reindeer management in Norway consists of approximately 3,300 persons who own about 210,000 reindeer (Reindriftsforvaltningen, 1998). During the 1980's, the development of Sámi reindeer management proved to be regionally diverse. What is particularly remarkable is that the lichen-rich winter and autumn pastures of Finnmarksvidda have become severely overgrazed. The overgrazing was connected with a considerable growth in total herd size. In addition reindeer management in Finnmark have produced low operating profits. Contrasting this, Sámi reindeer management in Trøndelag stabilized herd size, and also managed to keep operating profits on a high level. The study conducted (Riseth, 2000), tries to explain why the major technological change has been connected with overgrazing, resource depletion, and low yield in the region of West Finnmark. The total picture is complex and other studies have pointed to diverse explanations. Generally there seem to be no problem finding variables that at least have some

explanatory power. The challenge is to sort out which, in an array of factors, have the greatest influence contributing to the observed outcome.

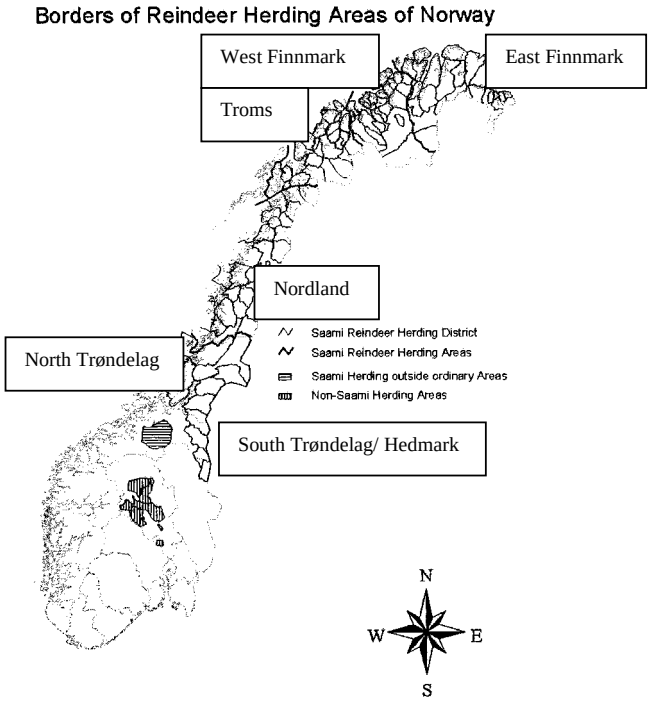

Figure 1. The area of Sámi Reindeer Pasture Rights divided into 6 Reindeer Pasture Areas. Source: Berge (1998:8).

2 Theoretical Perspectives

2.1 CPR Problems and their Analysis

Our theoretical approach takes its point of departure in the concepts of *common-pool resources* and *regimes.* Generally resources can be classified by whether they share the characteristics of *rivalry in consumption* and *difficulty of exclusion.* Common-pool resources (CPRs) are, like public goods, not easily subject to exclusion among the group of users. On the other hand, their consumption is rival, similar to private goods. This constellation of attributes is a potential source of problems as prevention of overuse is non-trivial (cf. Ostrom, Gardner and Walker, 1994:7). Potential CPR-problems can be analyzed with respect to two dimensions; their origin, and whether they are only stock-connected or both stock- and flow-connected. To mirror the connection between different types of problems, imagine an irrigation system with a reservoir. The main attributes of interest are that the system has an *inflow* (or a source of water), an *outflow* (a sink), and contains a *stock* of water. On basis of their source, one class of problems is related to the inflow, and another class associated with the outflow. The *inflow* class of the problems is related to the creation, maintenance, or improvement of the *resource stock*, that is, the cost of providing the services given by the resource. We denote problems related to the inflow as *maintenance problems*[3], cf. Table 1. The source of the problems is individual incentives to be free riders on the maintenance activities of others. The general problem for the

[3] Ostrom et al. (1994:9) use the term provision problems.

CPR user is to find the efficient level of his marginal costs of maintenance, equal to his marginal profit from use. Free riding of user A implies an increase in the costs or a reduction of total returns for user B. If B compensates by increasing his/her contribution, stock level is not affected, but the burden of labor and the outcome of the users can be highly skewed. For example, some users of a computer network may overload disk space but nevertheless be able to carry on if other users delete a greater part of their own files. In a time-independent perspective user A's free riding impose increased costs or reduced income on user B. We therefore denote this situation a *problem of skewed maintenance*.

Table 1. Potential CPR Problems

	IMPACT ON	
SOURCE	FLOW (Time-independent problems)	STOCK AND FLOW (Time-dependent problems)
INFLOW (Maintenance problems)	**Problem of skewed maintenance:** User A's free riding on User B's maintenance activity increases costs or reduces returns for User B	**Problem of insufficient maintenance:** Insufficient total level of maintenance due to free riding causes reduced stock level and reduced future harvest potential
OUTFLOW (Harvest problems)	**Harvesting externality:** The harvesting activity of User A imposes increased marginal costs or reduced marginal returns on User B thereby reducing his/her payoff.	**Over-harvesting externality:** Stock level reduced due to over-harvesting causing reduced regeneration and future payoff.

In a time-dependent perspective the implications are extended. If no one provides and maintains the structures that accumulate water into the reservoir, there is no water to use, for anybody. That is, the users face an environment in which the strategies they follow in one time period will affect the strategies open to them in later time periods. E.g., harvesting more than maximal growth in one period will contribute to stock reduction and thus lower possible harvest in the following periods. The problems become not only *flow*-connected but also *stock*-connected. If the problem is not satisfactorily solved, the yield from the CPR may be reduced and the users face the *problem of insufficient maintenance*[4].

For most CPRs, the most apparent potential problems are, however, connected with the *outflow* aspect of the CPR and its allocation. These externalities may or may not have implications for the resource stock. They are associated with such basic questions as, *who is going to harvest the resource, how, and how much*? "The problems to be solved relate to excluding potential beneficiaries and allocating the subtractable flow" (Ostrom et al., 1994:9). In the irrigation system example, these problems are thus related to the use of water. The cluster of potential problems relating to withdrawal of resource units from the flow of resources provided by the CPR may be called *harvest problems*. This set of problems is related to the flow out from a resource stock or the output of a production process and can also encompass both time-independent and time-dependent problems. The general problem for each user or appropriator is to find the efficient level of harvest equating his/her marginal costs with the corresponding marginal returns. Here user A's increased harvest reduces the outcome for user B. If the harvest

[4] Ostrom et al. (1994:14) denote this as a supply-side provision problem.

rate exceeds the regeneration rate (outflow is greater than inflow), the resource stock can be reduced. This happens when inflow and outflow are positively correlated and create *over-harvesting externalities*. A reduced regeneration rate and stock level will reduce the harvest potential for the future.

The typology introduced in Table 1 is inspired by, but deviates from, the one provided by Ostrom et al. (1994:8-15). We started out with the Ostrom et al. typology, but finding two weaknesses made us formulate another: (1) most important, one class of problems, our type over-harvesting externality, falls into two of their types simultaneously, "appropriation externality" (ibid.:10) and "demand side provision problem"(ibid.:13), which we found confusing, and (2) it does not cover our problem type skewed maintenance.

The four types of Table 1 give a *general* typology. The harvesting problems can, following Ostrom et al. (1994:9-12), each be divided into two specific subtypes, including specific additional conditions. By assuming diverse production capabilities of the natural environment, we can localize the particular subtype, *assignment problems*, which mean potential competition for "hot spots". “Hot spots” are locations of higher productivity than the average, with the inherent possibility of inefficient use of the CPR (Ostrom et al., 1994:11, cf. Gordon, 1954:131-132). For example, the maximum sustainable yield derived from different parts of a pasture may differ. Situations where some users are better off than others due to differences in productivity are not externalities; an assignment problem emerges whenever the "hot spots" become overused and the "cold spots" underused and the overall outcome is reduced. Harvesting problems can also be what Ostrom et al. (1994:12) call *technological externalities*[5], where use of one type of technology changes costs or productivity for users of other technologies. Assignment problems and technological externalities may reinforce existing harvest problems or be the direct reason for the emergence of new problems. We can also imagine that these two subtype problems can reinforce each other. For example, the introduction of new technology may promote hot-spot competition. We will consider combined stock- and flow-connected CPR problems to be more serious than problems that are only flow-connected.

Complex CPR-problems

Different CPR problems do not necessarily exist in isolation. We therefore introduce the concept *complex CPR problems*, meaning *problems caused by various harvesting and maintenance problems in combination, reinforcing each other*. Let us look at a couple of possible reindeer management examples:

(1) Insufficient herding implies reduced herd control and tameness grade and as a corollary increased difficulties conducting husbandry tasks, including harvesting. To the extent harvest is incomplete, this may initiate or strengthen already existing harvesting externalities, and thus promote development of an over-harvesting externality. That is, *insufficient herd control may imply insufficient harvesting*.

(2) We can also imagine combinations of assignment problems and technological externalities. Building on the example of grazing out of season on lichen pastures, we can assume that the potential overgrazing would not take place with the current herding technology. *The implementation of new technology as ATVs could advance the grazing out of season by making it feasible*.

[5] The notion *technological externalities* is in standard resource economics (cf. Baumol and Oates, 1988) used for externalities due to physical interconnections, as opposed to *pecuniary externalities*, externalities caused by financial matters. The two meanings of one term are a bit confusing. I have still chosen to use the concept here as my use is in accordance with the CPR-literature.

Combinations of different CPR problems may be an even more serious threat since *an apparently insignificant problem may develop to a serious one through various domino effects*. Whether the potential problems will develop or not is dependent on both the physical attributes of the CPR, production technology, the actors, and the availability of institutional solutions. We will now study how technological change influence potential CPR-problems.

IAD Framework

In order to translate complex real world situations, with the variety of properties held by resources and regimes, into situations more accessible for analysis, we need tools. We have chosen to use the *Institutional Analysis and Development* (IAD) *framework* (cf. Berge, 1998; Ostrom, 1990; Ostrom, Gardner, and Walker, 1994, Thomson 1992).Within this framework actors can be analyzed in action situations, as in a formal game. However, different real world variables, both ecological factors and institutional variables constitute this game. The actors in an action situation make up the formal part of the IAD framework that can be analyzed as a game. However, this formal game is constituted by different real world variables. The set of variables shaping the action arenas and also the actors are grouped into two main factors (composite variables or vectors). These are the attributes of the *physical world*, and *institutional factors*, which can be divided further[6] into the attributes of the *community*, and *rules-in-use*. The interplay of these factors and the characteristics of the actors together compose the action arena.

Ostrom et al (1994:47) specify rules and analysis at different levels (constitutional, collective-choice and operational). There is a dialectic motion between the operational and the higher levels of analysis. Institutional transactions (Bromley, 1989:128), activity to change the rules of the game, belong to the class of collective-choice activity. To study how an action situation on operational level may interplay with the action situation on collective-choice level, we introduce some additional concepts.

Evaluating institutional capacity

The action situation for a given common-pool resource includes a basic dynamics between the resource base and its users. The character of this interplay will define the *need for coordination*[7] by institutional arrangements. Changes in this basic dynamics may change the call for coordination. What will be critical for a resource management regime is its institutional *capacity to create compliance*. Long-term viability of common-property institutions will presuppose a balance (a system equilibrium[8]) between, on the one hand, a *need for coordination* and, on the other hand, a *capacity for coordination.* Starting with the need side, this may encompass as well biological, technological as socio-economic properties. Biological growth rates and growth patterns can be fundamental. This fact will thus contribute to the increase of the need for coordination for a CPR based on whaling. Generally uncertainty about factors like minimum threshold population, actual stock size, harvest rates, and the existence of random factors may

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6 In Ostrom et al. (1994) "Attributes of Community" and "Rules-in-use" are treated as two sets of autonomous factors. We will underline that the main difference is between physical and institutional factors.

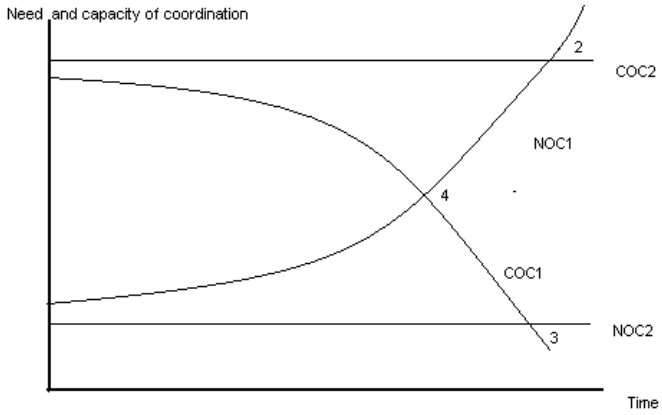
7 This concept is related to "demand for institutional service" used by some authors (e.g. Lin and Nugent, 1995: 2319, cf. 2325). Because "need for coordination" involves an objective of sustaining a resource, even though the resource value is low I prefer to avoid directly market-related concepts as "demand", and "supply" of institutions.

8 An institutional equilibrium would be a situation where none of the actors would find it advantageous to devote resources to pursue institutional change (cf. North, 1990:86).

promote over-harvest to exhaustion (cf. Perman et. al., 1996:181) and will conduce to an adding need. Among the social factors, the number of potential users is of course fundamental for the need of coordination. Runge (1992:19-21) points to relative poverty, critical dependence of natural resources, and uncertainty with respect to income streams as stylized characteristics of village life in less-developed countries. These are all factors that may increase the need for coordination. Further many resources are or have been well safeguarded by nature itself, i.e., through the size, location, inaccessibility or volatility of the CPR in relation to the technological possibilities of its appropriation. This setting would be typical for what Howe (1979:62) defines as frontier economies. A good illustration of this is the fisheries of northern Norway, which did not become a threatened resource until the new technological opportunities of the era after the Second World War appeared (Brox, 1990:231).

The capacity for coordination is a feature of the user group and the regime they have established. We would expect the number and the *homogeneity* of the appropriators to affect the capacity for coordination. The smaller and more homogenous the user groups are, the tighter the social relations and level of shared strategies will tend to be, and thus the lower the need will be for coordination through a set of enforced rules (cf. the concept *local commons*, Seabright, 1993). The capacity of the institutional system is generally dependent upon clarity in defining users/owners, their rights and duties, and the corresponding duties of non-owners. The set of rules also needs to be adapted to the physical attributes of the resource and the actual harvest and production technology. Imbalance between coordination *need* and coordination *capacity* may have both external and internal sources. Ostrom (1998:41) points to rapid exogenous changes, including technological, factor availability, and heterogeneity of participants, as possible threats to the continuance of any self-organized system. Ostrom (1998:42-43) also calls attention to *transmission failures* ─ rapid changes of population or culture leading to "a circumstance in which the general principles involved in the effective community-governed institutions are not transmitted from one generation to another." This can undermine the community of understanding, on which the interpretation of formal rules ultimately rests and create opportunity for opportunistic interpretation and behavior promoting institutional erosion, thus reducing the capacity for coordination.

On observing an empirical CPR problem, first we usually observe a *deficit* of institutional coordination. To explore the problem we need to examine the relation between need and capacity. Figure 2 depicts possible major development patterns leading to imbalance between these factors.



NOC_1 and NOC_2 are alternative curves for need of coordination, while COC_1 and COC_2 are alternative curves for capacity of coordination. The numbers 2, 3 and 4 mark the COC/NOC intersections where imbalance of coordination may emerge.

Figure 2. Need and capacity of coordination as functions of time

The figure leaves us with four possible situations:
(1) No Problem ($COC_2 > NOC_2$)
(2) Problem because of increased need ($NOC_1 > COC_2$)
(3) Problem because of decreased capacity ($COC_1 < NOC_2$)
(4) Problem because of both ($COC_1 < NOC_1$)

The problem situations emerge at the COC/NOC intersections and are marked with their relevant numbers in the figure. As the need curve usually is connected with observable physical factors, at least to some extent, changes in need would be the easiest to observe; that is we would probably observe a change of the NOC_1-type, for example the introduction and spread of new technology. Due to the difficulties of observing the capacity for coordination, a pure institutional factor, it would often be hard to distinguish between situation 2 and 4. We have to ask whether the deficit of capacity in relation to need also involves decline of capacity. Situation 3 could be either a transmission failure or the result of a undermining external pressure. For as well situations 3 as situation 4 we may need to examine the institutional history to find answers and choose possibilities at different points in time. Our ability to find answers depends on whether there is reliable data that may give us a picture of past coordination capacity of the institutions involved.

2.2 Problems related to Ecological Factors (Production system)

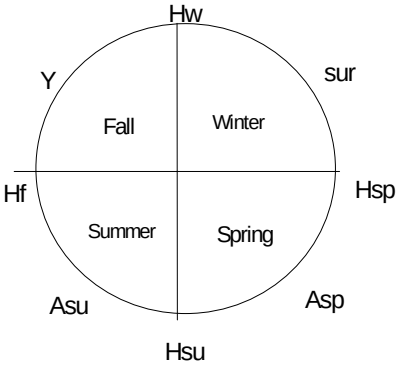
In applying the IAD framework perspective on reindeer management CPR problems we found a division between the *production* system the *institutional* system to be advantageous. The focal point of the production system has to be *the interaction of composite production factors*, e.g. pasture geography, pasture-herbivore interaction, and production technology. Skonhoft (1998) uses a standard Rosenschweig-MacArthur-type type predator-prey model when comparing herd sizes and harvest rates for North and South regions in Sámi reindeer management in Norway. This model, which is a herbivore-one-pasture model, was insufficient in explaining why overgrazing took place in the one case, but not in the other. Elaborating on standard models we have developed a mathematical *herbivore two-pasture model* to capture interseasonal pasture dynamics.

An important feature is the difference between summer and winter-feeding. The main diet during winter is lichens having their optimal growth when grazing is limited, while most summer feeding plants (herbs and grasses) can be relatively heavily grazed one year without this affecting the pasture capacity of subsequent years. Grazing on average more than the annual growth of lichens will reduce standing crop. This dissimilarity implies different dynamics between pastures and herd for different seasons. In addition, different seasonal pastures also have specific ecological roles. *For northern ungulates the capacity of the winter pastures are considered to limit herd size while the potential of green pastures (summer) decides the exploitation of the growth and production potential of the herd via each animal* (Klein, 1968); known as *the Klein hypothesis*. Using this as a basis we have sketched a simplified annual cycle, cf. Table 2.

Table 2. Seasonal herd concepts and events

SEASON	*HERD*	*EVENT*
Winter	Winter herd (H_W)	Survival rate (sur)
Spring	Spring herd (H_{Sp})	Spring accumulation rate (A_{Sp})
Summer	Summer herd (H_{Su})	Summer accumulation rate (A_{Su})
Fall	Fall herd (H_F)	Harvest (Y)

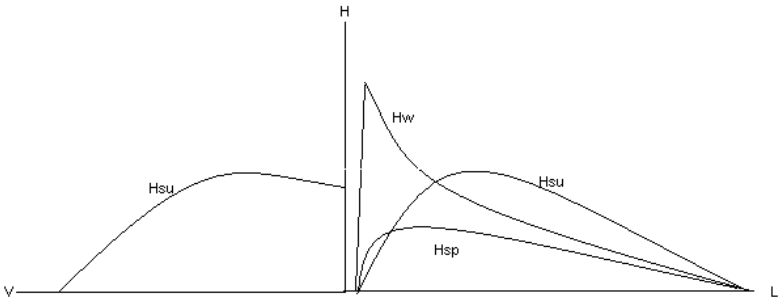
The connections are further illustrated in Figure 3.



Hw=winter herd, Hsp=spring herd, Hsu=summer herd, and Hf=fall herd.
sur=survival rate, Asp=spring accumulation, Asu=summer accumulation and Y=Yield

Figure 3. An annual cycle of herd dynamics.

Conditioned perfect balance between seasonal pasture capacities, the mathematical model developed can be depicted graphically as in Figure 4.



L is Lichen biomass. V is summer pasture biomass. H is herbivore biomass.

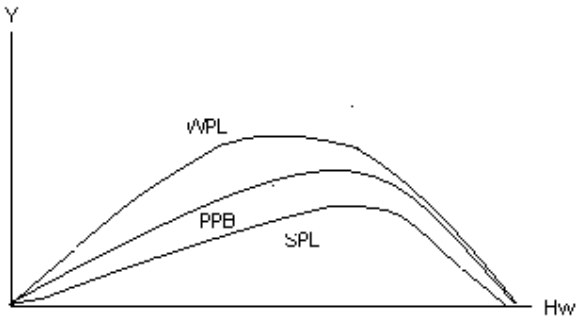
Figure 4. A stable pasture balance situation

The right-hand-side has three curves; for winter herd, spring herd, and summer herd. The latter is the crucial one, representing herd size (more correct: herbivore biomass) entering summer pasture. When this herd size equals the summer vegetation zero-isocline[9] on the left-hand-side, the pasture capacity of each season pasture fits the herd dynamic requirements exactly. That is; the summer herd on the right-hand-side $H_{Su(Y(L)Max)}$ equals the summer herd $H_{Su(Max)}$ on the left-hand-side. This is marked by the summer herd-line in the figure. The adaptation is stable.

Deviating balance situations create variation in output function, cf. Figure 5. For the situation of *winter pasture limitation*[10] *the output is consistently higher than the output for the standard situation* (perfect summer and winter pasture balance). A CPR with winter-pasture limitation also has its output maximum at a lower herd size than the standard situation. The stronger is the winter pasture limitation, the clearer are these features. Thus a winter pasture limited CPR can support a *smaller* herd than the standard situation, but *each animal will be more productive*. The situation of *summer-pasture limitation*[11] *will*, on the

[9] The herd size (herbivore biomass) exactly grazing the annual regrowth (neither overgrazing nor undergrazing)
[10] Winter pasture is limiting factor
[11] Summer pasture is limiting factor

contrary, *tend to have a lower output than the standard situation for all herd sizes*. The maximum output is also found for a relatively higher herd size than the standard situation. Thus a summer pasture limited CPR can support a *large herd, but with low productivity per animal*.



WPL is winter pasture limitation, PPB is perfect pasture balance, SPL is summer pasture limitation

Y is output (yield) when there is no over/undergrazing

Figure 5. Output as a function of winter herd size for various pasture-balance situations

Further a situation of summer pasture limitation could promote grazing out of season and lichen pasture overgrazing to depletion. Whether this is feasible, depends on landscape structure. As *landscapes without natural borders* require the most intensive herding (Ruong 1982:69), the tendency for grazing out of season will also be higher in such landscapes than *landscapes with natural borders.* Imagine the case of a summer pasture limited CPR hosting a relatively large herd with low productivity. In a landscape without natural borders between summer and winter pastures adjacent pastures could be used out of season, thus removing the limitation set by the capacity of each of the seasonal pastures.

Kinds of Labor: Herding and Husbandry

Individual animals can be hunted or tamed, but in our context *herd control* is the relevant point of departure. Control can be exercised both on herd level and on individual level. Basic herd control means human control over the movements of a group of animals usually ranging from a few hundreds up to several thousands by means of direct physical contact between man and animal or indirectly by means of various technologies. This work called *herding* (Paine, 1964:83), constituting the bulk of the labor, is carried out collectively by a group of cooperating herders. In the collective part of the work should be included not only strictly herding tasks, provision of common facilities like fences and corrals, but also defense and improvement of property rights.

In addition to this, *individual* control is exercised when the herd as such is under control, e.g. in a corral. *Work operations providing and securing the output for the individual owner* (e.g. earmarking of calves, castration, slaughtering) are subsumed under Paine's (1964:85) notion *husbandry*. The performance of husbandry tasks thus is conditioned upon sufficient herding. There are no established terminology characterizing husbandry work in dimensions of intensity, so we have chosen to classify husbandry in levels of *how intensive the exploitation of the herd's biological growth potential is*. That is, the husbander can by his decisions of life and death for individual animals design a herd with a herd structure, composition in age, sex and other characteristics (growth potential being one of them), in accordance with his goal of production. The technological level of husbandry can thus be increased by: (1) increasing the proportion of female reindeer relative to bucks, and (2) by

increasing the herd turnover rate by earlier slaughter (e.g. standard slaughter age could be changed from 2 1/2 years to 1 1/2 year) as growth rate is highest early in life.

Herding is traditionally conducted with very simple technology (cf. Paine, 1994) as bells on some animals, dogs to drive animals, simple fences out of natural materials, with skis and draught reindeer as the only means of transportation. Modern society and the opening of external markets for sale of reindeer products provided for import of new types of herding technology. The introduction and spread of the snowmobile was followed by a series of other vehicles as cars, all-terrain-vehicles (ATVs), and to some extent helicopters.

Implications of change in herding technology

In our model increasing the level of herd technology increasing grazing efficiency by at *winter pastures will contribute to decrease in output,* and should therefore be considered unprofitable. When stepping outside the model, we can imagine that increasing the level of winter herding technology by *increasing herd control* could be advantage of various reasons. For *summer pastures* our model will promote *increase in output, and at an increasing rate*. Furthermore, relevant for summer herding technology, we found that the clearer the winter pasture limitation is, the higher the output becomes. This means that *the change most favorable for output increase is to increase grazing efficiency at summer pasture to create a pasture balance change from a summer pasture limitation to a winter pasture limitation.*

Investment in herding technology bought on external markets obviously implies increased monetary costs. These costs are related both to acquiring the machinery and to its operation. We assume that investment costs are relatively high and that there will be a necessary minimum in herd size, which may be denoted *subsistence minimum* (cf. Beach, 1981), to cover the initial investment, and the total cost curve will thus intersect the Y-axis. The total operating costs are assumed to be increasing linearly. Revenue and a possible cost function are depicted in Figure 6 for a situation of summer herding technology investment.

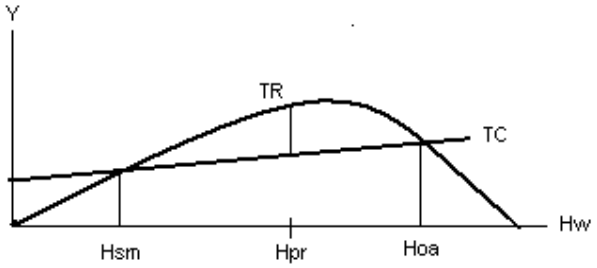


Figure 6. Implementation of summer herding technology. Cost and revenue curves. Possible equilibria.

The total cost curve intersects with the Y-axis, indicating the investment cost, and intersect the revenue curve at two points, creating two possible zero-profit situations. The lower is the point of subsistence minimum, H_{SM}, and the higher is the non-institutional (open access) equilibrium, H_{OA}. A maximum profit equilibrium is the institutional (property rights; here a common property regime) equilibrium solution, H_{PR}, at a herd size lower than H_{MSY}. This is in accordance with general theory*; under effective property rights the size of the investment will on a more moderate level ensure maximum profit, while we under open access will have an over-investment to the level of zero profit.* Generally we predict that investment in summer herding technology increases output. *In an environment of effective property rights the investment in summer herding technology will be to the level found profitable. Under open*

access the investment in summer herding technology will be up to a level producing zero profit.

A complex CPR problem

Let us consider *an environment of open access*; an increase in the level of herding technology may create a powerful dynamic. A herder obtaining a higher level of herding technology, with an immediate competition advantage in herd and pasture control compared to the herder with the lower herding technology level, may promote the development of a technological externality. This advantage can only be levelled out by the adaptation of the technology by all potential competitors. *New herding technique facilities will thus have a tendency to expand quickly forcing all co-users to invest in order to avoid loss in competition* (cf. Riseth, 1987:18-21, cf. Paine 1994:155*).* The investment thus becomes a necessary entry-ticket for new participants. We may thus imagine that in an open access environment, this will imply reinforced competition, which will tend to promote the process of increasing the over-all herding technology level. Consider *a series of herding technology investments*: in addition to the need for herd increase because of increased costs, the strengthened herding capacity also strengthens everybody's power to compete for the use of pasture resources. Thus the technological externality introduced above will not tend to disappear, even if the imbalance in herding technology level is leveled out.

Moreover, we will expect the competition to be sustained and the externality to reappear on a higher level (for example, skiers against snowmobiles, and later helicopters against motorbikes). Accordingly *the externality generally tends to be a treadmill forcing the users to pursue the herding technology level of the most advanced user, or lose in the competition for pasture and herd resources*. We should observe the resemblance to "The Agricultural Treadmill" (Cochrane, 1958, cf. Borgan 1981:208) in competitive investment, but also the great difference: the object for the competition is not a market, but the basic resources. However, one important implication is similar: both industries will tend to propel out surplus labor force. *Due to this treadmill effect, the open access equilibrium is not stable* as in Figure 6. We face a complex CPR-problem: a *technological externality promotes an over-harvesting externality more serious than the standard type*. The effects are most serious for the case of grazing at lichen pastures out of season. *Not only is the rent depleted economically, but also the vulnerable lichen resources are step-by-step more intensively exploited by an increasing herding technology level*. Each new level of herding technology makes possible a level of resource exploitation not feasible before.

While in the open access case the level of herding technology was decided by the first successful implementer, *in the case of effective property rights there is no treadmill effect.* The herders can in this case consider whether increasing the herding technology level, by means of implementing new machinery, is profitable or not. This depends on the shape of the revenue and cost curves. The reason is that with effective property rights the herders do not compete over the pasture resources. In effect, *for the case of effective property rights, new herding and husbandry techniques will be implemented if they are profitable.*

We have now developed a basis for inference on how reindeer management may adapt to technological changes. Assuming that herders invest in new herding technology of reasons external to the model, we predict that they will have two alternatives for how to cover the increased costs. The one option is *herd increase*, while the other is *productivity increase* through new husbandry technology. We denote the first option as an *expansive strategy* as it requires extension of the available pasture, and the second as a *stabilizing strategy* as it focus thew structuring of the existing herd. Specifying externality theory for reindeer management I

use the model derived and develop hypotheses on how different factors of nature geography and ecology may influence herder adaptation strategies under technological change.

We have scrutinized the potential of different technologies. We found two options with potential of revenue increase: (1) investment in summer herd technology, (2) increase in husbandry technology. Another option is (3) to *increase herd size*. This option implies overgrazing and pasture capacity reduction, but it can be feasible, at least in the short run. The option is nevertheless attractive as herding technology increases the potential of herd control. Characterizing these options, we know from above that option (1) can be profitable under effective property rights, or it can give zero profit under open access and even contribute to lichen pasture depletion through a treadmill effect caused by a complex CPR - problem. As for option (2) this can be profitable under effective property rights, but will provide no attractive opportunities of any externality under open access. As for option (3) this will be profitable and unproblematic if herd size is under the herd zero isocline (of the limiting season pasture). When this isocline is transgressed, the option can cause an over-harvesting externality under open access, while it is unattractive in the case of effective property rights.

Can these options be combined? On comparing the characterics we note that option (1) can be implemented under both regimes, producing different outcome. The remaining options (2) and (3) are on the contrary mutually precluding each other when the herd zero-isocline is reached. That is; we can consider *options (2) and (3) as opposite strategies of revenue increase*. We therefore denote as *Strategy A increase in husbandry technology* implying *expansion in productivity or quality*, while we name as *Strategy B increase in herd size* implying *expansion in quantity*. We note that Strategy A is stabilizing, promoting options in accordance with the given set of zero-isoclines, while Strategy B challenges stability by inducing overgrazing. Let us now inquire under which conditions these two strategy options are probable choices. Strategy A is equivalent with increasing the herd zero-isocline, while Strategy B is equivalent with transgressing the limiting pasture zero-isocline; being promoted by open access. It seems obvious that the tendency of choosing a stabilizing strategy is stronger, the stronger is the limitations of the situation. That is; in our two-pasture model *in situations of winter-pasture limitation* (and situations with similar features), we would *expect Strategy A to be the dominant choice*. This is because the lower is the expected level of winter survival, the lower will the propensity to pursue herd expansion tend to be. Similarly, for landscape, a landscape with natural borders having by itself a stabilizing effect would also promote a stabilizing strategy. Generally we would expect *stabilizing physical attributes and stabilizing strategies to be mutually reinforcing.* Conversely we would expect the tendency to choose strategies promoting instability (Strategy B) to be strongest when the limitations of such strategies are weaker. That is, in our two-pasture model, in situations of summer pasture limitation or in a landscape with relatively few natural borders.

We would expect these attributes of the physical world to promote Strategy A and herd stabilization:

(H1) *When winter pastures are the limiting factor in seasonal pasture balance, Strategy A and herd stabilization will be promoted.*

For landscape we can consider brokenness both within one seasonal pasture and between seasonal pastures. Within one seasonal pasture we have:

(H2a) *A landscape broken up by many natural borders, yielding relatively small-scale CPRs, will tend to promote Strategy A and herd stabilization*

Conversely the opposite features will favor Strategy B. Between seasonal pastures both a more macro scale and interseasonal borders can have an effect. We would expect that:

(H2b) *In the case of large scale CPRs, lack of or insufficient borders between seasonal pastures would tend to favor Strategy B and herd expansion more than for a small-scale CPR.*

2.3 Problems related to Institutional Factors

Common-pool resources can be operated under various regimes, particularly as common-property or under *open access* which is non-property. In a simple fishery model an optimal individual strategy under open access, would be to increase fishing effort until the resource rent is dissipated at the point where total harvesting cost equals total revenue. For enforceable property rights, including *common property*, the effort level producing maximal profit is found at a point where the slope of total costs equals the tangent of total revenue.

By analyzing the set of rules defining property rights, regimes of varying strengths can be described. Schlager and Ostrom (1993:14-24) have classified property rights arraying property-right regimes, distinguishing between more and less extensive common property regimes. The bundles of rights include both operational rules and collective-choice rules. Schlager and Ostrom progress by combining bundles of rights constituting *positions* in a cumulative manner. The positions thus vary from full co-ownership to authorized user, which is the position nearest to no-property. They (ibid.,1993:24) predict theoretically that CPR users would be more inclined to invest in institutions governing their entry and harvest if they have a more complete bundle of property rights. By inspecting a number (30) of cases involving fishermen and containing both a CPR dilemma and well-documented rules-in-use, the authors found a clear connection between *the extension of the bundle of property rights* and the fishermen's *ability to resolve common-pool resource dilemmas*. That means that CPR users being "owners," are much more inclined to solve common problems than "authorized users."

Sources of property rights are often diverse. The juridical notions *de facto* and *de jure* rights define different sets of rights, which may overlap, complement, or be in conflict with each other. As rules-in-use, *de facto rights*[12] are defined and enforced by the collective of the users themselves, while *de jure rights* are defined and given lawful recognition by government authorities (Schlager and Ostrom, 1993:19). De jure and de facto rights can be considered as two realms or communities of understanding (and enforcement) that may or may not happen to intersect. We would presume the situation of a partial intersection to be the usual.

One implication of this is that a user group may have different positions in the two rule systems. For example; fishermen, who are recognized only as authorized users by the government and thus having the *de jure* rights of access and withdrawal, may themselves execute *de facto* rights of management and exclusion as *de facto* proprietors. With this they may be perceived as fully legitimate within the local community (ibid: 19). *De facto* property rights are important for several reasons. A striking feature is that what are *apparently unregulated commons* (open access) for outsiders *can be effectively regulated with* de facto *regimes.* Failures to recognize this may be fatal in certain cases, as governmental regulations may be created which destroy well-functioning systems. *De facto* regimes are often closely matched to the physical and economic conditions of a CPR, implying low regulation costs for the users.

We have inquired different features (cf. Riseth, 2000) that can characterize herding societies in a minority context. These include the possible effects of missing markets and the traditional regimes of the CPRs. In particular we consider regulatory principles as common

[12] De facto rights can also be described in terms as customary rights, folk law or people's law.

basic ideas governing thought and activity in so-called acephalous societies. Moreover we consider the minority-state encounter and discuss the particular middleman relations, which can develop and influence the people's ability to resolve CPR dilemmas. We have developed the following set of hypotheses:

(H3) *When markets play a peripheral role in the economic life of a herding society we would expect a propensity to herd accumulation and also find Strategy B more usual than Strategy A.*

(H4) *Herding CPRs, which (a) belong to a society stressing collective responsibility in its set of regulatory principles, and (b) have a strong common-property regime with effective monitoring and sanctioning, will have a higher probability to pursue Strategy A and herd stabilization than herding CPRs having the opposite features.*

(H6) *The following characteristics of a co-management system can promote that its effectiveness:*
(a) mutual trust between the parties,
(b) the appropriateness of both the local and central institutional system, and
(c) economical and political gains for both parties.

Co-management systems (cf. Berkes, 1997) will usually not be complete and designed at a *tabula rasa*. Rather, they will often be partial and operate in combination with both informal and traditional *de facto* institutions and formal governmental *de jure* institutions. Whenever that is the case, it is the total fit of the institutional system, which matters.

(H7) *The higher the overall consistency of a regulatory system, the higher will the capacity of coordination for the operating regime tends to be.*

2.3 Problems of Creating New Institutional Capacity

Whenever a deficit of coordination capacity emerges, a process of regime breakdown may be initiated. Another possibility is through collective *action* to adjust the regime. Whether the emerging imbalance has an external or internal origin, the challenge will be to increase the institutional capacity for creating compliance by strengthening established institutions, developing new institutions, or a combination of the two. Thus there is a need for transformation (of the institutions). We will label the ability to increase the institutional capacity (for creating compliance) *capacity for transformation.* The design and adoption of new institutions to solve CPR problems are difficult tasks in any setting, but situational variables are important. Ostrom (1990:211) lists, approximately in order of importance, factors positively related to rule improvements. They are: (1) a common judgement among most appropriators of *being harmed* if rules are not changed, (2) *similar impact* of new rules on most appropriators, (3) *low discount rates* for most appropriators, (4) relatively *low* information, transformation, and enforcement *costs*, (5) presence of initial *social capital* in the shape of shared generalized norms of reciprocity and trust, and (6) a relatively small and stable *size* of the appropriator group.

Turning to the problem of *rebuilding transformation capacity*, we consider the examination of the prerequisites for creating sustainable economic development on contemporary American Indian reservations (Cornell and Kalt, 1990). In short, when basic preconditions like resource base, human capital — in the sense of skill and expertise — and market opportunities were fulfilled, the institutional challenges were summed up to be the achievements of: (1) sovereignty,[13] which more generally can be interpreted as autonomy, (2) leaders serving their

[13] Liberation from federal dominance.

people as a whole rather than their personal or subgroup interests,[14]and (3) effective governance, i.e., implementation, and incentive systems by means of formal and informal mechanisms which accord with the *people's cultural feeling of what is appropriate*. What seems to be crucial is the cultural part; reliable leaders and a strong political position externally are inadequate if the new authority system does not obtain a hearing with the cultural repertoire of the people. Culture serves as "collective templates that describe how they can and should organize themselves and respond to the political, economic and social conditions they encounter" (ibid: 37).

Seeking to reveal the conditions for sustainability of common-pool resources, Ostrom (1990:90) has made an analysis of resource regimes which are self-organized and self-governed and have proven to be long-enduring. She suggests eight *design principles*[15] for long-enduring CPR institutions. Two of them are about core operational rules and their relation to the physical domain; clear external boundaries and access rights and other operational rules that are adjusted to the physical attributes of the resource. One of the principles directly focus what we have called balance between need and capacity of coordination. Most principles are concerned with various aspects of creating an *internal autonomous collective level* under the ultimate control of the appropriators themselves, including an *authority system* and mechanisms of rule change. We have developed the following set of hypotheses:

(H5a) *The more developed is the general understanding of the need for implementing change, the higher will the capacity of transformation be.*

(H5b) *The existence of leaders who can find and implement solutions that are considered culturally appropriate will tend to enhance the capacity of transformation.*

Generally a condition for successful implementation of efficient public policy in a state-minority encounter, is that the responsible state actors really pursue goals of bridging the gap in culture and power. This will require some amount of cross-cultural understanding. Thus the minority representatives must have good reasons to trust the system before it can become effective.

(H8) *The higher is the level of cross-cultural understanding among the responsible state actors, the higher will the capacity of transformation tend to be.*

Making the connection back to landscape we can add:

(H2c) *An open landscape with relatively large scale CPRs will promote a community with a lower capacity of transformation than the converse.*

3. Research Design

The methodological approach chosen is a particular type of comparative analysis selecting observations with particularly high and low levels of the dependent variable for the chosen areas denoted North (West Finnmark) and South (North Trøndelag and South Trøndelag/Hedmark). The study is exploratory where the main objective is to focus main patterns. The main part of the data used is already published material. Parts of the material are collected through the author's previous work in the public reindeer management administration. To fill holes in established knowledge specific fieldwork is undertaken. The fieldwork encompasses interviews with elderly herders, extension workers and file studies. In the analysis we consider reindeer management as

[14] Avoid rent - seeking from leaders.

[15] Conditions accounting for the success of institutions in sustaining the CPRs and achieving compliance to the rules-in-use from an array of successive generations of appropriators.

a system exposed to external influence, particularly that of technological change. In the comparative analysis we observe the outcome of dependent variables as pasture biomass and income and aim to discern how difference in response to similar external influence can be explained by systemspecific explanatory variables. These variables are the naturegeographic and institutional variables developed in the theory part.

The analysis is conducted in three stages. First, we set the stage by presenting elements of nature geography, cultural and political history for Sapmi and Norway up to around 1960. Second, we focus the interrelations external influence, the CPR situation and the development of the production system by confronting the observed differences between the two regions studied. Third, we turn to the problem of explaining why North and South has adapted so differently to the similar external pressure, focusing the need and capacity of coordination and the full set of explanatory variables (cf. Appendix). That includes comparing each factor and testing every hypothesis against our empiric material. Comparing the effects of different factors we aim to discern possible differences of importance for the explanatory factors.

4 Empirical Analysis

Sapmi, as a geographical area, is far more heterogeneous than most northern landscapes, and well suited for reindeer; particularly Finnmark with highly accessible lichen pastures at winter. The Sámi reindeer culture is ancient and has been through a number of transformations through the centuries, so also the type of reindeer management. The latest phase of reindeer pastoralism up to the 1960's also perform some regional variation. The institutions of the Sámi herding society can be described in terms of regulatory principles and rules-in-use and seem to be fairly well adapted to the requirements in the period up to the major technological shifts in the latest third of the 20th century. We found that the traditional position of the Sámi reindeer herder to be near to the one of a full co-owner as a de facto position.

As a result of the negative governmental policy (cf. introduction) reindeer management was up to the period after the Second World War imposed to give way for agricultural expansion by the neighboring peoples. *Contrasting the internal de facto position, Sámi reindeer herders were de jure treated as nothing more than authorized users*. The Sámi organized; and started to achieve some progress in the postwar period. For the period from the 1960's on the South contrasts with the North in that it has stabilized pasture utilization and developed high income. External influence, public policy included, has mainly been the same for both the North and the South. We have inquired the development of the production systems in the two regions. Generally the snowmobile introduction started a fundamental change in herding technique which to a great extent solved the control problems of the postwar period, which had been most serious in the South. On the other hand, the technological development put reindeer management in a potential cost-price squeeze which led to two possible responses: (1) *herd expansion* or (2) *productivity increase*.

4.1 State of the resources

Studying the development of both lichen pasture biomass and reindeer herd size can reflect the North situation. Figure 7 provides a time series panel of North satellite images on (a) the combined fall/spring pastures and (b) on the winter pastures. For the interpretation we need to know that (a) is in the North (up) and (b) is in the South (down) and that the border between them about follows the road between the two centers Kautokeino and Karasjok. Starting

considering the 1973 panel we note that the overgrazing starts in the northwest; only parts of the fall/spring pastures are still affected. Turning to the 1980-panel, a larger part of the same area is affected. From 1980 to 1987/88, a rather dramatic shift seems to take place: 1) most of the fall/spring pastures become heavily overgrazed and 2) most of the winter pastures are also clearly affected. In 1996 fall and spring pastures are all heavily overgrazed, and only a minor part of the winter pastures has a fully intact lichen cover.

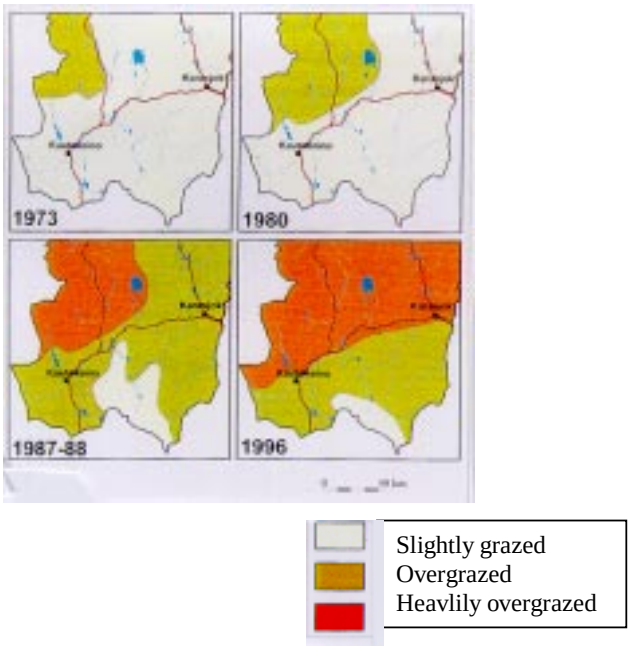


Figure 7. Changes in the lichen carpets of Finnmarksvidda 1973-1996 (Source: Johansen and Karlsen, 1998)

Figure 8 demonstrates registered North herd size for the period 1969-1995. Levels over 60000

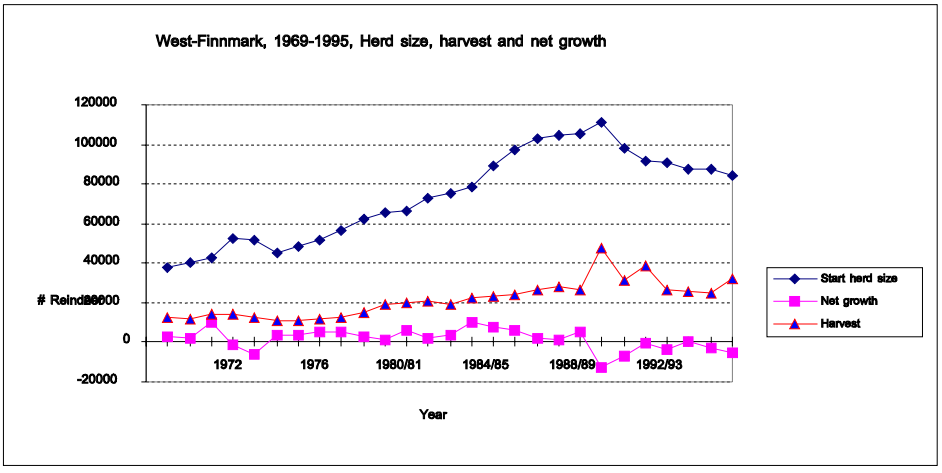


Figure 8. North herd size development (cf. Riseth 2000).

are historically new for the area. The South area do not have overgrazing in this period (cf. Riseth, 2000).

To picture the husbandry development in both regions we include Tables 3 depicting key numbers of herd productivity in the two regions compared.

Table 3. Meat production per animal in spring herd (April, 1).
North Trøndelag and South Trøndelag/Hedmark (South) and West Finnmark (North)

	1976	1984	1987/88	1993/94
NorthTrøndelag	8.1 kg	10.5 kg	12.9 kg	14 kg
SouthTrøndelag / Hedmark	12.5 kg	16.3 kg	14.8 kg	14 kg
West Finnmark	7.8 kg	8.9 kg	7.0 kg	8 kg

Source: Kosmo, 1991:20 and Reindriftsforvaltningen, 1995:38.

Above we have found a distinctly different development pattern in the North and South regions where the main choice of the North was *herd expansionism*, and the main one of the South was *productivity increase*. Further while the South situation seems to resemble the game of Assurance, the North situation seems nearer to that of Prisoners Dilemma. For the North an analysis of the internal development substantiates a complex CPR problem where herders having their summer pastures most adjacent to fall/spring pastures were the winners in a competitive overgrazing of the lichen pastures.

4.2 Comparison of need factors

Studying historical herd size development patterns in Norway and Fennoscandia, we found a parallel in the general development of reindeer management in Finland, which also reached a historically new herd size level due to artificial winter feeding (cf. Kumpala, 1998). Generally we suggest:

(C1) *A major and permanent herd increase to a distinctly new and higher level is improbable without a major change in the production system as facilitated through a technological change.*

Further we confronted our empirical observations with our hypotheses one by one, and compared the outcome. There is a clear difference between the regions, and our hypothesis (H1) that winter pasture limitation will promote herd-stabilizing strategies cannot be rejected. Our material suggests that this may be an important factor of explanation. We conclude:

(C2) *Herd expansion (Strategy B) seems to be promoted by the existence of summer pasture limitation.*

The regions are clearly different both in landscape and performance and our hypotheses cannot be rejected. We conclude:

(C3) *Herd expansion (Strategy B) seems to be promoted by the existence of a relatively open and borderless landscape, in particular by lacking or insufficient borders between seasonal pastures.*

(C4) *We do not have any indications that market relations influence herders' choices between the Strategies A and B.*

(C5) *Internal recruitment pressure could contribute, though not being necessary factor, to a upward shift in need of coordination.*

The need factors are compared in Table 4.

Table 4. South vs. North contrasts in need factors

H#	Factor	Regional difference	C#	Possible contribution
(H1)	Pasture balance	Clear contrast	C2	Seems important
(H2)	Landscape structure	Clear contrast	C3	Seems important
(H3)	Missing market	No difference observed	C4	No test possible
	Demography	Clear contrast	C5	Probably contributing

The table says that we have no indications that market relations influence herders' strategy choices. The clearest findings in our material is that pasture balance (H1) and landscape structure (H2) both seem to be important for the explanation of herders' strategy choices. These choices influence the development of the production system and thus indirectly need of coordination. In addition we have found that the control variable demography (in North) probably also contribute to the increase in need of coordination. We will now focus the interaction of (H1) and (H2). For the variables *pasture balance* and *landscape* we have found the main pattern that *in the South both are such that the choice of stabilizing strategies becomes easier, while in the North both work in favor of expanding strategies*. Thus, both or only one of them may be necessary for the choice of strategy. Let us see if we can distinguish between the importance of these two factors. Analytically we can show this as a two-by- two-matrix depicting pasture balance on one axis and landscape character on the other as in Table 5.

Table 5. Possible combinations of Landscape and Pasture Balance.
Stable and expansive combinations.

Pasture balance	**Winter pasture limited**	**Summer pasture limited**
Landscape structure		
OPEN	Stable North 2000 (?)/Finland 1970	Expansive North 1960-1970
BROKEN	Stable South –main pattern	Stable South- coastal

For pasture balance, on the horizontal axis, we recall that a winter pasture limitation restricts the herd expansion potential. If the winter herd zero-isocline is transgressed her size cannot expand due to increased mortality. Landscape structure is depicted on the vertical axis. We note that the strictest condition on each of the axes is the Southwest corner. Going into the matrix we start with the combination winter pasture limitation and a broken landscape, which is the South main pattern. Here we have a double limitation. The opposite situation is the combination summer pasture limitation and open landscape, which was the North situation at the start of the technological revolution; a double low level of physical limitation.

The combination *summer pasture limitation and broken landscape* is the example in our material, we have registered as breaking with the main pattern; the South coastal summer pasture limited districts where herds do not expand. In this setting it is only the landscape that limits the expansion potential. The landscape has natural borders and a moderate scale; there is no place to expand. Thus Strategy B is not feasible. It seems, as winter *pasture limitation is not a necessary condition for limiting herd expansion since the landscape can set the limits.* This indicates that *an overgrazing of the observed West Finnmark magnitude is not especially*

probable in an area with the South configuration. This conclusion also include the coastal areas having summer pasture limitation. The other possible deviating combination is *open landscape and winter pasture limitation*. Assuming that the contemporary North in fact has become winter pasture limited, North 2000 is an example of this combination, as well as the mentioned Finland example. We can imagine a West Finnmark 1960-situation of abundant summer pasture resources and scarce winter pastures. How would the herders then have adapted during the technological revolution? It seems improbable to graze out of season pasture at summer when there is abundant summer pasture resources. Herd size would probably adjust to lichen pasture capacity (the possibility of some grazing at fall/spring pastures would not be dramatic when there is snow-cover). In the West Finnmark 2000-situation the total herd size is not increasing; the empirical test of whether this is due to winter pasture limitation, is to start supplementary feeding and observe whether total herd size will increase in the future, similarly to Finland in the 1970s and the 1980s.

As we have found empirical examples of all four possible combinations, we can suggest that *the observed North herd increase is dependent upon both the features of summer pasture limitation and open landscape*. As a conclusion:

(RC2&3) *Successful implementation of Strategy B seems to be dependent on the co-existence of (a)summer pasture limitation and (b) a relatively open and borderless landscape, in particular by lacking or insufficient borders between seasonal pastures.*

Considering need of coordination in an overall perspective, we have found three factors that we will consider necessary for a major increase in need of coordination. Of the three necessary, but not sufficient factors, the technological revolution itself (C1) is in the position of being the triggering factor of the whole process. The factor works both the increase herd control abilities and through a cost-drive that create a need of increase in revenue. The two ecological factors co-work as the summer pasture limitation (C2) is necessary for creating the need of grazing out of season, while the pasture scale and border-condition (C3) is necessary to make grazing out of season feasible. The recruitment pressure (C5) has probably speeded up the whole development process, but we find that the process would most probably have gone on also without this pressure.

4.3 Comparison of factors of capacity of coordination

The rapid development in herding technology from the middle of the 1960's represents a strong challenge to the North capacity of coordination. In other words, a considerable increase in the capacity for coordination would have been *a necessary condition if North herd size had stabilized during the 1970's and the 1980's.*

As for the need factors we also compared capacity factors between the two areas. We started with comparing traditional regimes (cf. H4), and did not find significant differences, as there were considerable internal variation in both regions. Studying ideology we found that *even though expansionism is not a focused ideology of the contemporary South, its existence can be revealed both as ideology and as historical events.* In spite that *South adaptations of the last decades are relatively uniform and herd stabilizing, the traditional regulatory principles do not seem be different from those if the North.* In both regions, the balance between individuality and collectivity seems to be able to tilt either way. Thus we do not find sufficient empirical support to maintain a stand of a significant difference in the North and the South regulatory principles. As a conclusion:

(C6) *We do not have clear indications that regional differences in traditional regulatory principles have contributed to regional differences in herders' choices between the Strategies A and B.*

Thus we did not find support for the first part of our hypothesis (H4) and now turn to the second part. Generally we have not found enough or clear enough differences between the two regions we are comparing to ascribe them explanatory power for differences in capacity of coordination. As a conclusion:

(C7) *We do not have clear indications that regional differences in traditional regime have contributed to regional differences in herders' choices between the Strategies A and B.*

Locally the South contrasts the North very clearly in general attitude towards the extension service. In the South many herders actively sought cooperation, while in the North the main attitude seems to be that the work of the extension service did not seem very relevant. In the negotiation system of reindeer management and in the governing system of boards, particularly on the top level (cf. Riseth, 1992) trust seems to have been built during the period, regardless of the regional background of the parties. We may conclude:

(C8a) *When mutual trust between herders and extension workers exists, this seems to have been a factor contributing to strengthening the capacity of coordination.*

(C8b) *We do not have indications of regional differences with respect to mutual trust between government and herder representatives, and cannot infer whether this is a factor that has contributed to regional differences in the capacity of coordination.*

Even though not everybody in the South was entirely positive to the regulations, we have not detected any public protest. On the contrary, the regulations mainly seem to have been accepted. Even so we have not found traditional cultural South-North differences. However, there are clear *historical differences*; South herders have had a dialogue with governmental representatives for a longer time, and there was *a widespread wish for changes*. Thus during the period of our study, *South herders seem to some extent having changed their mind from traditional attitudes towards being in favor of regulations; because they felt the regulations to be necessary*. As we were not able to document significant regional differences in traditional regulatory principles and regimes (C7), *ideological differences between the regions seem to have developed in the period 1960-1990*. The outcome from this was that *while in the South the new institutional system mainly was felt to be appropriate, it was to a significant degree felt inappropriate in the North.* As a consequence of this; in the North the system was considered fully legitimate, and the regulations to a considerable degree became rules-in-form. We can conclude:

(C9) *When the institutional system was felt to be appropriate and thus legitimate, the new co-management system seems clearly to have contributed to increase in capacity of coordination.*

Politically both the government and NRL gained from the system, in the early 1980's; before the public became aware of the malfunction for Finnmark. The government was under pressure for its general Sámi policy, and NRL was in need of results. The change in policy in the late 1980's obviously was necessary for the trustworthiness of the parties. The implications of the malfunctions can be concluded:

(C10) *As (a) the government had defective understanding of the real function of the regulation system, and (b) followers of Strategy B interest in its malfunction, this seems to have constrained capacity of coordination.*

Seeing institutions as successive layers of structuring, the overall institutional system of the 1980's consists of three layers; the traditional system, the law-based regulations and the agreement-based regulations. For an effective total system these layers should reinforce each other. The intention of the law regulations was thus to mend "holes" in the traditional system. However, this was not an easy task. As we found above, many North herders did not find the regulations very legitimate. This impeded both their implementation and their effects.

Marit Fjellheim (1986) has studied the subsidy system of the Reindeer Management Agreement and has found a high degree of inconsistency in the subsidy system itself. The inconsistency meant that efforts to solve one problem the one year created new problems the subsequent year. Reforms of the subsidy system in the late 1980's (see above) included cleared standard requirements for receiving subsidies; as to slaughter the annual herd increment. The coordination between Act and Agreement was also improved. The system at the beginning of the 1990's thus had considerably fewer holes than the one during the 1980's. The inconsistencies of the system clearly had a more important impact in the North than in the South, which mainly had adapted to the system, e.g. by developing the quota system by local design of quotas based on household size by reallocation (without increasing the total quota.

In addition there were not full correspondence with the law- and the agreement system. In the early 1980's it was not a requirement for receiving subsidies to have adapted to law regulations. This "hole" was also mended by the "tidying" in the late 1980's. We can conclude:

(C11) *When imperfect overall system consistence, this seems to have been a constraint upon the capacity of coordination.*

In comparing North and South, the external pressure towards the Sámi reindeer management has been clearly greater in parts of the South than the North. The South Sámi, particularly in the Røros area, are still exposed to a considerable external pressure. Other parts of the South, as North Trøndelag are more in a medium position; neither very much pronounced conflicts nor close relations. Our expectation was that strong external pressure would promote undermining of the regime. The experience is, on the contrary; *strong external pressure strengthened the regime and promoted stabilizing strategies.* One reason for the failure of our expectation may be that we did not imagine concretely the relation between resource competition and border conditions. However, North Trøndelag, which has not been exposed to this strong external pressures also pursued stabilizing strategies. This fact is an argument against strong external pressures being a necessary factor for the revolution of herd productivity. We need to consider this in a broader context of internal South comparison. Preliminarily we can make the following proposal:

(C12) *When strong external pressures from resource competitors, this has contributed to strengthening of the internal management regime, and thereby increased the capacity of coordination.*

In Table 6 we have compared the observed differences if capacity of coordination. From the table we can sum up four major findings related to the capacity of coordination: (1) no clear indications of difference in effect of traditional regime (C6 and C7), (2) no clear indications of difference in effect of the co-management system on organization – government level, (3) clear indications of difference in effect of co-management system for the herders (C8a, C9-11), and (4) effects of external resource pressures for South Trøndelag/Hedmark (C12).

Probably *all the factors mutual trust (C8a), appropriate institutional systems (C9) and strategy B-followers' interest in malfunction (C10b) seem to be important, and influencing the capacity of coordination.*

Table 6. Observed differences with respect to capacity of coordination development

H#	Factor	Regional difference	C#	Possible contribution
H4a	Regulatory principles	Not different	C6	No clear indications
H4b	Internal strength of regime	Not different	C7	No clear indications
H6a	Mutual trust-herders vs. extension service	Clearly different	C8a	Probably contributing
H6a	Mutual trust- organization vs. Government	Not different	C8b	No clear indications
H6b	Appropriate institutional systems	Clearly different	C9	Probably contributing
H6c	Economical and political gain-government defective understanding	Clearly different	C10a	Probably contributing (negatively)
H6c	Economical and political gain-Str.B-followers interest of malfunction	Clearly different	C10b	Probably contributing (negatively)
H7	Overall system consistence	Clearly different	C11	Probably contributing (negatively)
	External resource pressures	Clearly different for Strøndelag/Hedmark	C12	Probably increasing capacity

4.3 Comparison of factors of capacity of transformation

The achievements of the reindeer managing Sámi is mainly as Industrial Policy and not so much through Minority Policy. This developed a capacity of transformation for the 1970's and the 1980's. This is a narrow basis and it is probably not sustainable when exposed to hard external pressure. However, this does not seem to have influenced the two regions we inquire differently in the period of our study. Our conclusions were:

(C13) *An open landscape and great scale CPRs, this might contribute to a lower capacity of transformation than the converse.*

(C14/15)*Where there is: (a) a general societal understanding of a need of internal change, and (b) an orientation of herder leaders towards finding solutions, this seems to have been contributing to the development of a society's capacity of transformation. Where(c) the society has a strong organization tradition the capacity of transformation is enhanced further.*

(C16) *We cannot conclude whether the level of cross-cultural understanding among state actors seems have influenced the capacity of transformation.*

5 Discussion and conclusion

We have inquired the development of the production systems in the two regions. Generally the snowmobile introduction started a fundamental change in herding technique which to a great extent solved the control problems of the postwar period, which had been most serious in the

South. On the other hand, the technological development put reindeer management in a potential cost-price squeeze which led to two possible responses: (1) *herd expansion* or (2) *productivity increase*. If the first option were chosen, herd size would at some stage confront resource limitations, leading to an increased resource competition. If the second option were chosen, the full utilization of the potential would require a change in cooperation which to some extent would break down the traditional division between herding and husbandry practice.

Empirically we found a distinctly different development pattern in the North and South regions where the main choice of the North was *herd expansionism*, and the main one of the South was *productivity increase*. In our analysis of how different factors could explain the contrasting North and South development pattern, we have analyzed three independent sets of factors, related to need and capacity of coordination and capacity of transformation, *within* each of these three sets. We will now bring all this knowledge together – i.e. we will discuss relative importance and try to illuminate possible interrelations.

Of these factors, the technological change itself (C1) is in the position of being the triggering factor of the whole process. The factor works both via an increase in herd control abilities, and through a cost-drive that creates a need of increase in revenue. The two ecological factors co-work as the summer pasture limitation (RC2) is necessary for creating the need of grazing out of season, while the pasture scale and border-condition (RC3) is necessary to make grazing out of season easier. If the total increase in need of coordination created by these (and other) factors is not met by a corresponding increase in capacity of coordination, there may emerge a deficit of coordination capacity, and the complex over-harvesting externality described theoretically will take place with overgrazing of lichen pastures. For the potential necessary capacity factors we concluded that the factors mutual trust (C8a), appropriate institutional systems (C9) and strategy B-followers' interest in malfunction (C10b) seem to be important, and influencing the capacity of coordination.

When observing an empirical CPR problem as a deficit of coordination capacity, the problem can have different possible origins. To find which is the most probable in our North case, we first have to track, so far as possible, the development of both need and capacity of coordination. We start with the need side and the main conditions for increased need (C1 and RC2&3). The technological revolution itself is a clearly observable process; that is *the need of coordination has obviously gone through an upward shift*, in both regions, however clearly *greatest in the North*.

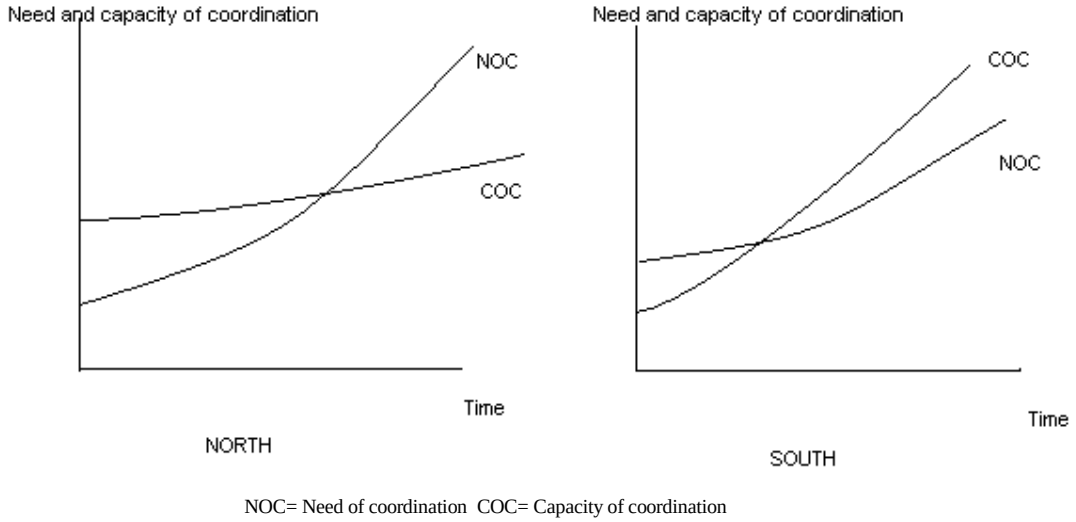
It is more difficult to assess the development of the capacity of coordination. However another comparison with the South can be useful. Even though the South do not meet either of the other physical conditions (C3, C4) for promoting Strategy B, obviously the need of coordination increased clearly also in the South. Since South did not develop a deficit of coordination capacity in the 1970's and the 1980, the South either had sufficient capacity of coordination or increased its capacity during the same period. Going back to our North South comparison of traditional regimes, we did not find clear differences, while the differences were very clear for the functionality of the co-management regime of the 1980's. As the South experienced control problems up to the 1960's and these were solved, the functionality of the co-management system is consistent with an increase in the capacity of coordination. As the traditional regimes seem to have been fairly alike in the North and the South, *the North capacity of coordination probably also was low in the 1960's,* however sufficient though.

In a comparison it seems as the main features are like this:

1) Need of coordination (NOC) has increased clearly both in the North and the South.
2) The NOC increase is undoubtedly much higher in the North than the South

3) The capacity of coordination (COC) of 1960 was rather low and fairly alike in the North and the South
4) The COC of 1960 was sufficient in the North and insufficient in the South
5) In the South the COC has increased clearly and sufficient
6) In the North the COC has not increased sufficient to cope with the increase in NOC, and there is a deficit of COC.

The development of the two regions is sketched in Figure 9:



NOC= Need of coordination COC= Capacity of coordination

Figure 9. Development trends in North and South needs and capacities of coordination.

Deficit capacity of coordination within a regime calls for the society's capacity of transformation. Recall that our main findings were:

(C14/15)*Where there is: (a) a general societal understanding of a need of internal change, and (b) an orientation of herder leaders towards finding solutions, this seems to have been contributing to the development of a society's capacity of transformation. Where(c) the society has a strong organization tradition the capacity of transformation is enhanced further.*

This seems as a good explanation for how the South managed to create new capacity of coordination. For the South all three points (a), (b) and (c) seem important. For the North we find it more difficult to draw a certain conclusion. For the capacity of transformation, point (a) the need of understanding, probably was the most important.

Conclusion

Having tested all our hypotheses and sorted out the factors we found to be the most probable as important to explain the North development in contrast with the one of the South. Above we have connected our main findings for need and capacity of coordination as well as capacity of transformation. We singled out a pair of physical features on the need side and three institutional factors on the capacity side, all three of them connected to the functionality of the co-management system established. The presence of the two institutional factors, mutual trust herders-extension workers (RC8a) and appropriateness of the institutional system (RC9) seem to be the outcome of societal use of capacity of transformation; which seem to have been used in the South. This seems to have contributed to a situation based on conditioned strategies. The

third institutional factor; interest in the malfunction of the co-management system (RC10b) may have restricted the use of capacity of transformation in the North. Thus, while the South seems to have created new capacity of coordination, while the North has not, at least not in a sufficient degree. It may be the case that dominant strategies have made existing capacity of transformation more or less irrelevant. The most important factors seem to be the physical features of the pastures and the capacity for transformation and its use. We may summarize (1) *The natural conditions for adapting to the technological change were more in favor of stabilizing strategies in the South, and (2) the South Sámi were also better prepared than their fellows in the North. In addition (3) winners of the North pasture competition and the setting itself, might have influenced the remainder of the herding society to not take actions.*

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Appendix

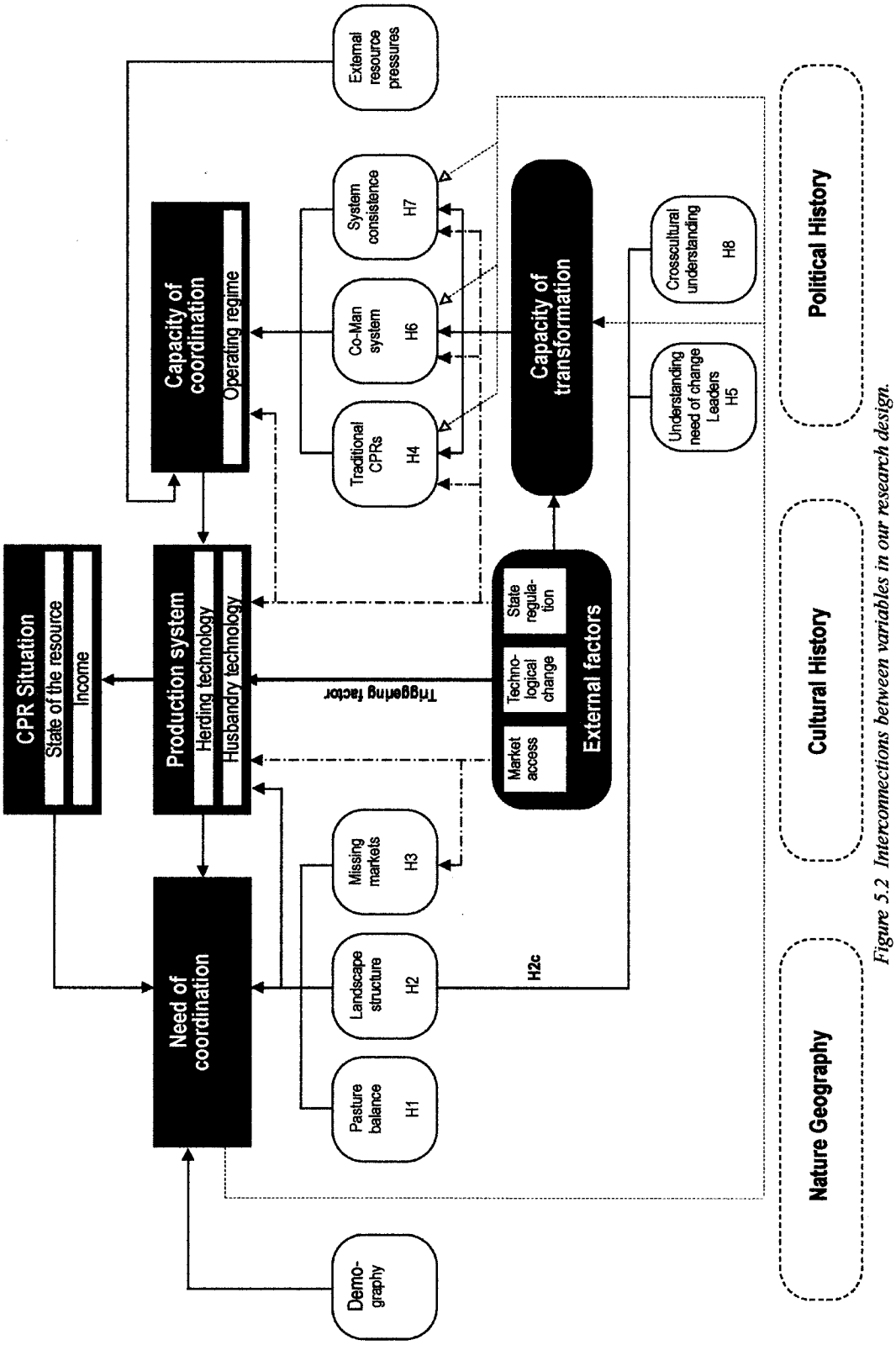

Figure 5.2 Interconnections between variables in our research design.