Sustaining Livelihoods with Livestock on the Pastoral Commons of Mongolia.

Abstract

Mongolian pastoralism continually involves decision-making by the herder to mitigate risk and avert disaster of greater or lesser proportions. Risk imposed by environmental conditions is always a factor in meeting animal demand and livelihood needs in a pastoral system. The demands of the animal to survive and be productive must continually be balanced with the availability of feed, water and shelter over several different but consecutively occurring time frames. Environmental risk can be mitigated individually and collectively through adaptive planning and decision-making processes. The pastoral production system, either individually or collectively, is less effective in mitigating risk derived from economic and social influence external to the production system. In non-pastoral animal production systems common to industrial economies, externally obtained physical and technical inputs are used to reduce the environmental and economic risk associated with livestock production. However, using inputs to overcome environmental risk, while possible in Mongolia, is very costly, and often forces the herder to assume greater economic risk without eliminating all of the environmental risk associated with livestock production in a natural economy. Dependence on inputs without the existence of a fully developed input and marketing infrastructure not only can increase risk but also can decrease long-term viability of pastoral livestock production. Flexibility of decision-making in animal production activities, mobility of adapted animals, and access to a variety of spatially and temporally distributed resources is the surest method of reducing livestock production risk and ensuring sustainable livelihoods in a true pastoral system. New co-management institutions capable of responding to internally and externally generated changes to pastoral livestock production need to be developed and employed.

A. Introduction

Pastoral Development.

There seems to be a general consensus that pastoralism originated as a result of a Neolithic revolution that produced a complex agricultural-herding society (Vainshtein 1989). The question remains as to whether farmer herders evolved into nomadic pastoralists or whether the appearance of nomadism was connected with new people coming into contact with established farmer-herder societies. Several suggestions put forth by Russian scholars addressed possible reasons for the transition from a complex farmer-herder society to a narrowly specialized herding economy characteristic of pastoral livestock herding societies. Possible reasons for the transition are: (1) an increase in livestock numbers and the accumulation of experience in migratory herding made nomadic pastoralism the most progressive option under these conditions; (2) periodic changes in landscape and climate, especially long-term droughts, forced previously settled farmer-herders to turn to nomadic pastoralism; (3) overpopulation in complex settled societies drove individual clans already inclined towards nomadism into a migratory way of life; and

(4) migratory hunting tribes obtained transport animals and domesticated livestock from settled farmer-herder societies and gradually developed nomadic pastoralism because the transition did not require a major change in the hunters migratory lifestyle.

For whatever reason, pastoral livestock production of some form has been the source of livelihood in much of Central Asia for centuries. Vainshtein (1989) cites Khazanov (1989) as believing pastoralism evolved from an agriculture or hunter/gather base following domestication of livestock and pack and riding animals, believes that communal ownership of land and water rights, combined with private or familial ownership of livestock is necessary to maintain a pastoral nomadic lifestyle. His thesis is that pastoralists must be able to move their herds freely in response to available forage. Even though land and water rights may be owned or controlled by an elite, as long as ownership or control did not include the right to sell land, continuation of the pastoral lifestyle is not threatened.

Murphey (1989) believes that most conflicts among intra-tribal nomadic groups centered on disputes over grazing rights. Forage was and is the basic and indispensable, as well as finite, resource of all pastoralists. The means of sustaining their livestock and, indirectly, their own livelihood, is not possible without access to forage. Forage supply is the critical resource limiting traditional and modern pastoral livestock production systems.

Many scholars, including students of pastoral societies today, refer to members of animal herding societies as being "nomadic pastoralists." However, in the true sense of the word, Mongolian herders are not nomads and have not been nomads for millennia. Jachin and Hyer (1979) state that " Although in premodern times, there was competition for grazing and gaming areas, the use of areas usually became set, and in normal circumstances trouble was avoided because seasonal migration is not haphazard or chaotic, but rather quite carefully defined. It is the *use* of land in a migrating society that is of greatest concern, not the *possession* of it."

Realizing that Mongolian pastoralists are not nomadic but rather are transhument pastoralists is important to the discussion of "common lands" as it applies to Mongolia today. Possession of land is not the most important driving force of a society engaged in pastoral livestock production; rather, having access to a diversity of foraging habitats (i.e., forage produced by vegetation communities interacting with climate and topo-edaphic characteristics of the land) and to water and shelter resources necessary to permit optimal livestock production has been the focus of Mongolian pastoralism. Direct land ownership or "de facto" ownership through long term leases of publicly owned land is not conducive to maintaining the traditional or even current system of Mongolian pastoral livestock production.

Prior to the Mongolian Revolution, access to land and natural resources was generally under the overall control of a relatively few entities-the nobility which employed herders and allocated resources to those herders or the Monasteries which controlled directly or indirectly much of the resources in the country. After the revolution but prior to

establishment of livestock collectives, the previous control of the nobility and church decreased but was replaced gradually by control of the state.

State control was firmly established over all resources in 1963 with the forced establishment of the livestock collectives and state farms. During this period, collective rights to commons under the direct control of the state superceded all rights of the individual. The state organized the livestock production system down to the level of the household with households and individuals in households having specific job specialties in livestock production. Time of use and area of natural pasture used were determined by decisions made at higher administrative levels. The state provided at cost (i.e.) many of the inputs used to maximize off-take from livestock production, including veterinary medicine, subsidized purchase, transport and delivery winter livestock feed supplements, and processing of livestock off-take products. The state determined yearly off-take "quotas" and arranged for transfer of meat, milk, and fiber products from the producer to the consumer. The Mongolian livestock herder was paid a salary and also received compensation "in kind" which included access to health care, education, and retirement pensions.

During the collective era, it is highly probable that the goal of achieving maximum use of natural resources for the purposes of livestock production was realized. The rural livestock collectives were also highly effective in organizing livestock production by livestock herders. However, even though pastoral grazing strategies were retained, the system was not economically sustainable and, in some areas, proved to be ecologically unsustainable (Sheehy 1996).

B. Current Context of "Commons" in Mongolia

The Mongolian constitution of 1990 retained public ownership of natural pasture land, meaning, that physical aspects of natural pasture resources cannot legally be privatized (i.e., the individual cannot legally acquire title to a defined area of natural pasture whereby other persons or entities can be excluded or denied access to the resource or forced to purchase access to the resource by leasing either land or the forage produced on the land). An exception to this is the right of livestock herders to retain some amount of natural pastureland near winter shelters for purposes of "hay-making" but the herder still does not have the right to sell the land used for haymaking. Consequently, all citizens of Mongolia have the right of free access to all land defined as natural pasture unless access has been restricted for purposes of national defense or placed into national parks or reserve areas to which access is restricted.

By "commons" is meant, at least in the context of the Mongolian livestock herder, access to the set of natural and artificial resources needed to sustain their livelihood directly and indirectly through animal production. A large part of "commons access" by a livestock herder is being able to use natural resources at temporal and spatial scales suitable for successful livestock production-forage for livestock produced on natural pasture, water

for livestock from rivers, streams, and springs, shelter for livestock such as shade during summer and topographic wind shelter during severe weather events.

Artificial resources of great importance to the Mongolian herder are winter shelters, which can significantly influence survivability of livestock during critical birthing and initial rearing periods. Water wells providing access to water in areas without surface water, especially in the desert steppe and desert regions are another type of artificial resource of great importance to livestock production.

New conditions are affecting the Mongolian livestock herder's perspective on use of natural resources for the purpose of livestock production and livelihood sustainability. The current approach to defining access and "commons" is a new approach that may be without precedent in Mongolian history. It is new because the "common man" is legally permitted under the constitution to use natural resources to support his livelihood, ostensibly as the person sees fit to do so. A second condition which influences both access to the "commons" and livestock production in general is the developing market economy.

A third condition is the "de facto" control of resources needed for livestock production. This condition is becoming a dominating feature of pastoral livestock production in Mongolia in the present, and has existed in the past. Sufficient historical references exist to indicate that a major activity of those who had access to natural pastureland during the historical period was controlling access by other entities trying to expand access to improve their own position. Although the current constitution provides equal access to all citizens, achieving access is not easy. Established herders, most of whom were firmly in place and with firm control of natural resources based on their former participation in the collective livestock production system, now control access to resources necessary for optimal livestock production.

Access to 'common" resources and herder responses to a market economy will directly and indirectly shape livestock production in Mongolia. In turn, both of these new forces through their effect on livestock production and herder responses will determine long term economic sustainability of livestock production and ecological sustainability of pastoral resources.

C. Pastoral Interactions

Access to natural resources, especially forage and the nutrients contained in forage, is the most basic requirement of a pastoral livestock production system. Gaining and maintaining access to forage requires the production system to have three primary components: (1) natural resources (i.e., attributes of the physical and biological environment or primary resources) capable of sustainable supporting a pastoral livestock production system; (2) livestock capable of processing and converting feeds (i.e., forage, hay, natural and indigenous manufactured supplements) to secondary products (i.e., milk, meat, fiber) at a rate sufficient to meet animal needs and provide a surplus that can be used by the pastoralism, and (3) the pastoralism who, through management expressed as flexible

decision-making, reduces the environmental risk associated with livestock production in an uncertain and often harsh environment.

Three primary interactions are simultaneously occurring between components of the production system. The first interaction is nutrition, which is an interaction between livestock and pasture resources and is determined by the quality and quantity of forage available to meet animal needs. The second interaction occurs in the application of grazing management strategies and is an interaction between the livestock herder, livestock, and pasture resources and determines access to forage within the biophysical environment. The third interaction is "livelihood" which is an interaction between the pastoralism and livestock and is determined by the amount of animal off-take surplus to the animal's needs that is available to the pastoralist. The three interactions simultaneously affect each of the three primary components of pastoral livestock production.

Nutritional Interaction

In Forest and Grass Steppe ecological zones, herbaceous plants (i.e., grasses and forbs) dominate vegetation types and constitute the primary forage available for grazing herbivores. Perennial shrubs tend to co-dominate with herbaceous plants in the Desert Steppe ecological zone and dominate the Desert Ecological zone. Consequently, interaction dynamics are different among the ecological zones, especially between the Desert ecological zone and the other three zones, which have greater composition of herbaceous plants. The graphic displays in figures 1 & 2 are referenced primarily to livestock production interactions between grazing management strategy, nutrition, and surplus off-take in Forest and Grass Steppe ecological zones. However, shrubs are present in all ecological zones and, where abundance is high, can affect or even alter production interactions because of the availability of usually highly nutritious browse (i.e., shrub leaves, buds, and twigs) throughout the annual production cycle.

In figure 1, there are three types of forage available to the pastoralists livestock during an annual production cycle: (1) Previous Year's Old Growth (PYOG) which is standing crop of herbaceous forage grown during the previous year's growing season, (2) Current Year's New Growth (CYNG) which is standing crop of herbaceous forage produced during the current years growing season, and (3) Next Year's Old Growth (NYOG) which is standing crop of herbaceous forage produced during the current year that has matured and is no longer growing. The pattern followed by CYNG herbaceous plants is: (1) initiate growth in mid to late spring, (2) grow rapidly during the summer frost-free period of maximum temperature and precipitation, and (3) complete growth (maturation and senescence) in late summer and early autumn. With maturation and senescence, herbaceous CYNG forage becomes NYOG forage during autumn and early winter. As a calendar and nutrition discussion convention, NYOG forage becomes PYOG at the beginning of the new year.

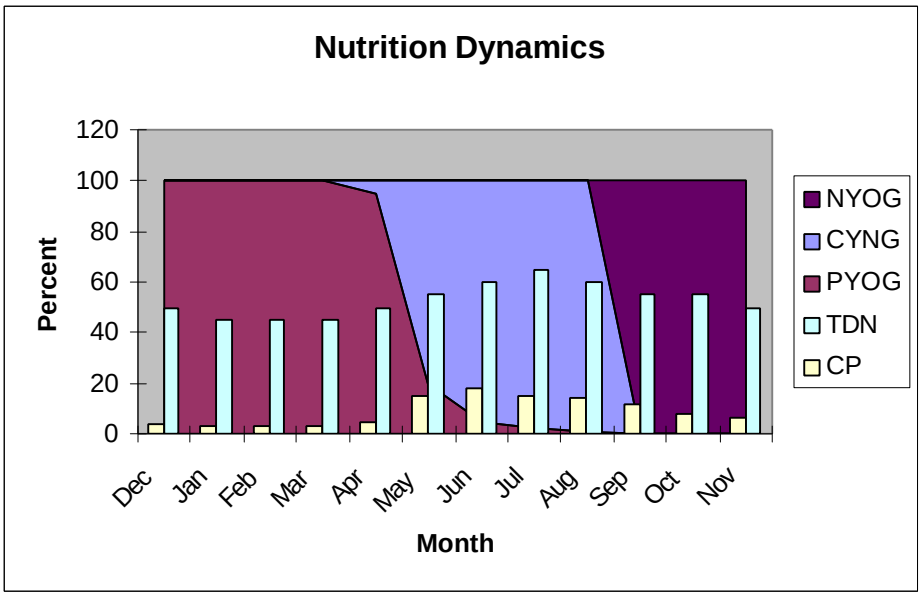


Figure 1. Annual supply of nutrients available for livestock production in the Mongolian pastoral system.

Columns in figure 1 represent potential nutrients available to the grazing herbivore throughout an annual production cycle. Crude protein (CP) and Total Digestible Nutrients (TDN) are highest in herbaceous plants during initial growth and throughout the active growing season. After the cessation of active growth (CYNG), physiological processes initiated by the plant or induced by weather changes generally cause CP and TDN values to fall. Herbaceous NYOG retains relatively high levels of CP and TDN but the amount available to grazing herbivores in Standing Crop is declining and continues to decline throughout the fall, winter, and spring. The decline in nutrients available to grazing herbivores is mitigated only with the initiation of growth by herbaceous standing crop forage in late spring.

Grazing Management Interaction

Figure 2 displays animal body condition dynamics throughout an annual cycle in relation to nutrient availability from forage standing crop. If body condition curves in Figure 2 were superimposed on Crude Protein and TDN availability curves in Figure 1, highest animal body condition occurs at the end of the growing season of CYNG in September and October when CP and TDN are still at relatively high levels in forage standing crop. The period between May and September when CP and TDN are highest in CYNG is critical for restoring animal body condition to a level sufficient to permit animals to enter estrous (breed) following low animal body condition in the spring. Unless the animal has access to sufficient quantity of high quality CYNG in late spring and early summer, estrous will not occur or will occur later during the summer growing season.

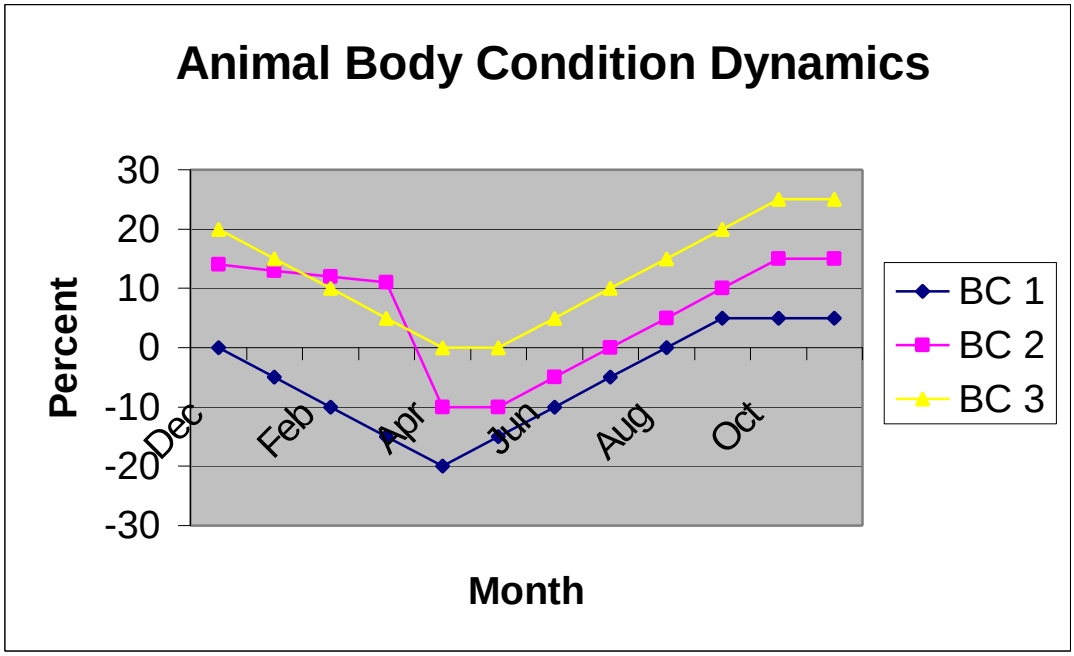


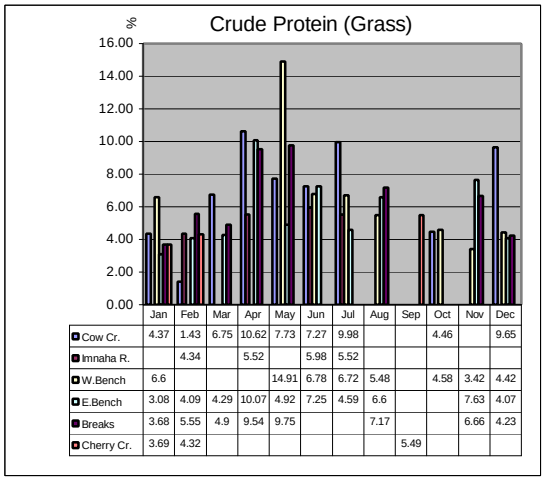
Figure 2. Relationship of animal body condition to nutrient availability in forage.

In pastoral livestock production systems, nutrition is important but being able to meet animal nutrient needs from forage standing crop at critical times is the key element of sustainable pastoral livestock production. The response of the pastoral livestock production system to environmental risk in temperate regions of the world has been to ensure that key events in animal production cycles coincide with the highest abundance of nutrients in the forage base. In a natural economy, birth of young animals need to coincide with initial growth which invariably has high nutrient content to support lactation by mature females giving birth.

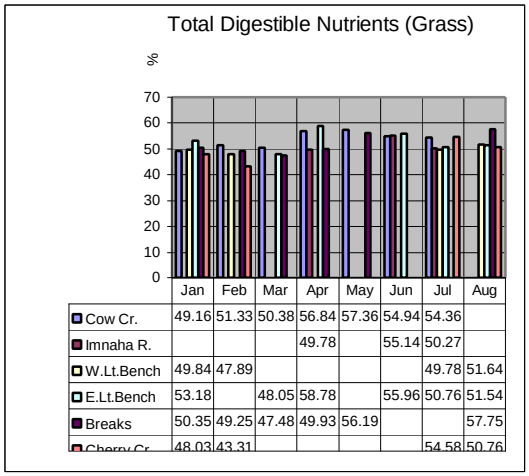
To ensure restoration of animal body condition and breeding even though the animal is lactating, large herbivores with longer gestation periods (i.e., approximately 9-10 months) need access to the abundance of nutrients provided by forage standing crop during the rapid growth period early in the vegetation growing season. Small herbivores, with greater dietary elasticity than large herbivores and a shorter gestation period (i.e., approximately 5 months), need access to an abundance of nutrients after completion of the vegetation-growing season and coincidentally with lowered ambient air temperatures. Access to abundant nutrients during this period can be ensured through a combination of livestock and grazing management strategies which include weaning of the young animals to reduce the nutrient needs of the lactating female and/or ensuring access of breeding females to vegetation containing high quality nutrients.

The interaction between forage condition and nutrient availability and between timing of nutrient availability and animal body condition is basic to all pastoral livestock production

systems. Figure 3 has actual nutritional data from a North American pastoral system in the Hell's Canyon of the Snake River. The relationship between grazing management and nutritional availability over an annual production cycle is obvious. Crude Protein (CP) and Total Digestible Nutrients (TDN) are lowest during the winter months when animals use nutrients stored as body fat for maintenance and highest during the spring months during parturition and lactation.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cow Cr.	4.37	1.43	6.75	10.62	7.73	7.27	9.98			4.46		9.65
Imnaha R.		4.34		5.52		5.98	5.52					
W.Bench	6.6				14.91	6.78	6.72	5.48		4.58	3.42	4.42
E.Bench	3.08	4.09	4.29	10.07	4.92	7.25	4.59	6.6			7.63	4.07
Breaks	3.68	5.55	4.9	9.54	9.75			7.17			6.66	4.23
Cherry Cr.	3.69	4.32							5.49			



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Cow Cr.	49.16	51.33	50.38	56.84	57.36	54.94	54.36	
Imnaha R.				49.78		55.14	50.27	
W.Lt.Bench	49.84	47.89					49.78	51.64
E.Lt.Bench	53.18		48.05	58.78		55.96	50.76	51.54
Breaks	50.35	49.25	47.48	49.93	56.19			57.75
Cherry Cr.	48.03	43.31					54.58	50.76

Figure 3. Nutrients in grass available to grazing herbivores during annual production cycles in a North American pastoral livestock system.

Livelihood Interaction

Both no estrous and late estrous have negative implications for sustainability of the livestock production system and its ability to provide surplus animal products supporting livelihood of the pastorlist. If estrous does not occur and the female animal does not breed as indicated by BC1 Curve in Figure 2, no young will be produced the following spring. In a pastoral livestock system, not rebreeding following birth and lactation of young animals is nature's method of ensuring that the animal will have achieved sufficient body condition to breed the following year. Without having to grow the fetus, the animal can restore body condition and store enough fat to allow the animal to retain a higher body condition through the winter and spring periods of low nutrient availability and have sufficient body condition during early summer to enter estrous and breed.

However, the number of animals available to support the meat, milk, and fiber needs of the pastorlist in the future is diminished. For pastoralists with limited livestock numbers, even a few mature females not breeding back in the summer following birth can be catastrophic to their livelihood potential. Equally catastrophic to the herder's future livelihood can be late season breeding of mature females as indicated by BC2 curve in figure 2. Late breeding of mature females indicates a lower than optimum level of body condition was reached by the animal during the winter and spring. As a result, birth of young animals will occur later each spring. The mature female will have less opportunity to restore body

condition and store body fat needed for winter survival. The late-born young animal has lower probability of surviving the rigors of winter and spring because of reduced body size, less milk supplied to the young animal by the mother because lactation is occurring during nutrient stress periods, and lowered ability of the late-born animal to compete with other animals for poor quality forage and nutrients.

D. Ecological Interactions

Grazing by large herbivores, especially livestock is generally regarded by western environmental groups and some resource management professionals as negatively impacting ecological condition of vegetation and stability of soils (Conner et al. 1998). The perspective that grazing has a negative impact is based on the widespread degradation of natural and agricultural ecosystems in North America that occurred in the late 19th and early 20th Centuries as a result of overstocking of rangelands and improper farming practices and the widespread degradation that is occurring in parts of Asia and Africa. Considerable time and effort has been spent formulating concepts and developing range management practices designed to mitigate the negative impacts of livestock grazing. Concepts and principles at the center of this discussion include carrying capacity, stocking rate, density-dependent factors, equilibrium and non-equilibrium environments, ecological condition and trend, success ional pathways, etc. Determining whether these concepts and principles apply to a pastoral livestock production system is important because they relate to sustainability of natural resource use by livestock on a pastoral commons.

Carrying Capacity

Carrying capacity has been defined as the number of healthy animals that can be maintained by habitat on a given unit of land (Mautz 1980). Key words in this definition are “number of healthy animals,” “habitat,” and “given unit of land.” The concept of carrying capacity as a resource management principle has utility if it is used in an animal context (i.e., healthy number of animals in a unit of land) rather than a vegetation context (i.e., vegetation biomass produced by a given unit of land to be partially allocated to a set number of animals for a defined period of time). Animals, and pastoralists, are subject to different spatial and temporal parameters than vegetation produced on a given unit of land.

Establishing a carrying capacity for a healthy number of animals has to be approached from a perspective of “over time” because the response time of populations of large grazing herbivores is long-term (i.e., several years) rather than short-term (i.e., seasonal within an annual sequence of growth, maturity, senescence, and/or death) characteristic of herbaceous plant populations. While determining carrying capacity in either a vegetation or animal context requires “trying to hit a moving target,” a carrying capacity based on animal body condition is feasible because animals respond to different time frames with slower rates of change. For example, all large grazing herbivores, including livestock, require at a minimum two years to reach maturity.

Coefficients that are commonly used to measure animal productivity (i.e., birth rate, survival estrous, mortality, fiber and meat and milk yields, etc.) do directly correlate with vegetative yield and nutrient availability but over longer time periods than the intra-annual time period governing forage and nutrient supply. Carrying capacity of livestock in pastoral production systems are especially dependent on and directly related to forage and nutrients obtained from vegetation that varies in amount and quality in relatively short time-frames. Large grazing animals have compensating mechanisms that allow them to "smooth out" the vagaries associated with supply of forage and nutrients obtainable from natural ecosystems. Mechanisms include: (1) "compensatory growth" whereby body condition rapidly improves because losses in body weight that occurred during periods of nutrient stress are replaced when supply of forage and nutrients is optimal, (2) the ability of large herbivores to lose 10-15 % of body weight without adversely affecting animal survival, (3) female animals not breeding in the following growing season if body condition becomes too poor during the winter and spring seasons, and (4) high animal mortality during severe weather events which tends to balance long-term forage supply and demand. Unless a catastrophic event occurs such as a severe weather event or imposition of "density-dependent factors" on the animal (i.e., too many animals using a unit of land without sufficient feed inputs available from external sources), a multi-year succession of less than optimal forage and nutrient supply is required to influence population survival of large grazing animals and ecological condition of the forage habitat.

An animal carrying capacity determined by measuring vegetation attributes (i.e., biomass, forage yield, forage nutrients) is possible and relatively accurate *for a point in time*. Determining a vegetation carrying capacity that will improve or ensure sustainable use of the vegetation *over time* by livestock in a pastoral production system is difficult. Carrying capacity based on vegetation yield of an artificially defined unit of vegetation does not consider the continuous change in forage standing crop or nutrients. Changes in animal behavior and needs are not accounted for in making carrying capacity determinations. Generally, livestock production using pastoral grazing management strategies are not capable of reducing or increasing animal numbers to change stocking rates to fit an annual vegetation carrying capacity.

The "carrying capacity" concept" fits well with western land tenure and land use systems. Land, including rangeland, has been divided into neat little chunks of a certain spatial area, which have no relation to physical or biological characteristics. Since we have only access to a neat chunk, our framework also approaches forage use from the perspective of a neat chunk-there are so many hectares which have the capability of producing so many kg of forage which will supply feed for so many animals (i.e., carrying capacity).

Grazing Impacts

Mongolian pastoral livestock production systems exist within the larger context of pastoral ecosystems in a cold temperate zone. The perception of how particular ecological systems operate determines the approaches that are advocated in attempting to modify or manipulate ecosystems (Ellis and Swift, 1988). A perception of many western

development institutions is that ecosystems occupied by pastoralists generally function as "equilibrial systems." Equilibrium ecosystems are regulated by animal density-dependent feedback controls that pastoralists often override to the detriment of themselves and the ecosystems in which they operate. An alternative perception that is gaining considerable acceptance among advocates of pastoralism is that many ecosystems occupied by pastoral production systems are "non-equilibrium systems." Pastoral livestock production systems in "non-equilibrium ecosystems" are controlled by external mechanisms and are not subject to feedback control mechanisms from within the system. Consequently, pastoral livestock production is the best and most stable form of ecosystem use

Ellis and Swift (1988) contrast equilibrium and non-equilibrium grazing systems in Table 1. Also in table 1, an attempt is made to place Mongolian pastoral grazing in the context of equilibrium or non-equilibrium grazing system.

Table 1. Mongolian Pastoral Grazing System Similarities to Equilibrium and Non-Equilibrium Grazing Systems (adapted from Ellis and Swift 1988).

	Equilibrium	Non-Equilibrium	Mongolian Pastoral Grazing Systems
Abiotic Patterns	a. Abiotic conditions relatively constant	a. Stochastic/variable conditions	a. Varies by ecological zone
	b. Plant growing conditions relatively invariant	b. Variable plant growing conditions	b. Varies by ecological zone but more characteristics of equilibrium systems.
Plant-Herbivore Interactions	c. Tight coupling of interactions	c. Weak coupling of interactions	c. Traditional pastoral plant-herbivore interactions are changing in some areas to tight coupling of interactions characteristic of Equilibrial systems as expansion and concentration of livestock numbers continues.
	d. Feedback control	d. Abiotic control	d. Abiotic controls continue to affect plant-herbivore interactions throughout Mongolia. In some areas, both feedback and abiotic controls are affecting plant-herbivore interactions.
	e. Herbivore control of plant biomass	e. Plant biomass abiotically controlled	e. Herbivore control of plant biomass developing in areas of livestock concentration.
Population Patterns	f. Density dependence	f. Density independence	f. Density dependence developing in areas with livestock and human concentration. Density independence in areas not subject to animal concentration.
	g. Populations track carrying capacity	g. Carrying capacity too dynamic for close population tracking	g. Expanding livestock and herder populations and concentration of livestock population, change in herd structure, decreasing mobility in livestock management are creating situations where populations track carrying capacity.
	h. Limit cycles	h. Abiotically driven cycles	h. Expansion of animal numbers and concentration of livestock are beginning to limit population cycles within an abiotically driven vegetation cycle.
Community/Ecosystem Characteristics	i. Competitive structuring of communities	i. Competition not expressed	i. Competitive structuring of communities in forest and grass steppe ecosystems; competition not expressed in desert steppe and desert ecosystems.
	j. Limited spatial extent	j. Spatially extensive	j. Ecosystems are spatially extensive but mobility of animals and access to ecosystems becoming spatially limited.
	k. Self controlled systems	k. Externalities critical to system dynamics	k. Externalities critical to system dynamics throughout the livestock production system.

The above contrast of equilibrium and non-equilibrium grazing systems supports the contention that the Mongolian pastoral livestock production system, which developed and has been sustainable under non-equilibrium conditions, is shifting towards livestock production characteristic of an equilibrium ecosystem. The Mongolian pastoral livestock production is changing as livestock herders and rural populations try to adjust to new socio-political and economic realities.

E. Pastoral Livestock Economies

Examining the Mongolian livestock production system in the context of 'natural economies" and 'industrial economies' is a useful mechanism to relate livestock production to issues of "commons" and sustainability (Lichatowich 1999). In an industrial economy, the natural resource base is overlaid and artificially divided by political and administrative hierarchies, competition exists among the artificial divisions for purposes of economic gain, a well developed production infrastructure exists and is driven by fossil

fuels and capital inputs, large scale and vertically integrated production facilities favoring monoculture production exist, and spheres of competing but independent economic interests develop (Table 2).

Conversely, in a natural economy, organization is by natural units of the landscape with boundaries imposed by natural constraints, the largest part of the production infrastructure is invisible, production activities are driven by solar energy and the need to reproduce, production is dispersed among small units, production activities are circular and renewable, consumptive use and recycling of production prevails, and natural resources are viewed as connected habitats for use rather than exploitation.

The traditional pastoral livestock production system is similar to a naturally functioning wild herbivore system and is more appropriately regarded as functioning in a natural economy rather than an industrial economy (similar to wild salmon as described in Lichatowich 1999). A difference between natural wild herbivore production systems and properly functioning pastoral livestock production systems is the layer of control and management exerted by the herder on domesticated herbivores. Control and management are necessary to ensure human livelihoods. However, the traditional pastoral livestock production system, including the human element, is subject to the same set of environmental constraints as wild herbivores. In the traditional pastoral production system, most human interventions (i.e., management) were made in response to some current or future impending environmental constraint and were an effort to mitigate the potential negative impacts on livestock directly and on the pastoralists livelihood indirectly.

The traditional pastoral production system evolved as part of a natural economy rather than an industrial economy (Table). However, pastoral livestock production during the rural collective and state farm era had many characteristics of an industrial economy even though pastoral grazing strategies were retained as the primary livestock management and production methods.

Rather than an organized, intentional, and politically mandated attempt to “industrialize” livestock production, problems associated with change in political and economic systems is providing the impetus to move the neo-traditional pastoral production system into an “industrial” economy. This move is occurring even though attributes of livestock production are generally characteristic of a natural economy. Externally induced stimulants originating from new socio-economic and political paradigms are affecting sustainability of the pastoral livestock production system that is still organized and dependent on the decaying physical and psychological infrastructure developed during the socialist era. For example, the shift in herd structure to Cashmere goats is more characteristic of an industrial economy than a natural economy because the shift occurred for economic reasons. .

Table 2. Livestock Production in a Natural Economy Versus an Industrial Economy (Adapted from Lichtowich 1999).

Industrial Economy	Natural Economy	Mongolian Livestock Economy	Change Factors
Livestock production in an industrial economy is organized into political hierarchies (countries, states, counties, cities, private homesteads)	Livestock production in a natural economy is organized into natural units (watershed, basins, mountains, and natural habitats defined by soils, vegetation, and topographic features, etc.) where use is defined by natural factors of the animal and the habitat.	Livestock production in the Mongolian economy is organized into political hierarchies (aimag, sum, & bag) but generally organizes actual livestock production according to natural units within the bag (watersheds, seasonal pastures, cooperative decision-making concerning access to forage)	Higher human population in the livestock economy is causing conflict over "de facto" possession of critical natural inputs (winter shelters, hay making areas, water sources, access to markets).
Livestock production in an industrial economy has political divisions competing and often conflicting over the ownership, use, and distribution of resources. Livestock are mere tools used to exploit natural resources for economic benefit to the owner.	Livestock production in a natural economy views livestock and natural resources as part of a co-evolving relationship. Boundaries are imposed by biophysical constraints. Livestock are the basis of livelihoods.	Livestock and habitat are viewed as part of a co-evolving habitat with boundaries imposed by biophysical constraints (seasonal ranges determined by topographic, vegetative, and climatic attributes of the natural landscape, knowledge of the interaction between livestock and natural resources critical for livelihood sustainability)	Change in political and economic systems is creating situations analogous to an industrial economy (natural parks and reserve areas, movements to assign ownership to components of natural resources critical for livestock production, conflicts over access and use of natural resources increasing, regulations defining livestock use of natural resources being prepared)
Livestock production in an industrial economy has a production infrastructure which is visible and recognizable, and its function is generally understood-animal rearing areas, feedlots, slaughterhouses, feed production, market channels, wholesale and retail chains. Livestock production depends on provision of inputs obtained externally to the local production infrastructure.	Livestock production in a natural economy has a production infrastructure, which is only partially visible, and its function, while poorly understood, is the basis of sustainable livestock production. Livestock production is low input and dependent on local resources	Livestock production in the current Mongolian economy currently has only a partially visible infrastructure. Inputs other than locally manufactured inputs are few (veterinary medicines, supplemental feeds, processing facilities, production to meet market needs). During the preceding collective era, livestock production on both state farms and rural collectives had a more visible infrastructure.	The change in political and economic systems is fostering infrastructure development (introduction of higher yielding livestock breeds, increase in Cashmere goats to meet international market demand, development of marketing centers). Development of a more visible production infrastructure will increasingly be driven by social and economic considerations affecting the rural human population rather than livestock production considerations.
Livestock production in the industrial economy is driven by fossil fuel and the need to accumulate capital.	Livestock production in the natural economy is driven by solar energy and the need to reproduce.	Livestock production in the Mongolian economy is currently almost entirely driven by solar energy and the need to reproduce. . Forage is the basis of livestock production. Nutrients obtained from forage determine livestock production coefficients such as mortality, survival, estrous and birth rates, which affect livelihood sustainability of rural populations.	The need to market products over long distances and the transport of households between seasonal pastures is an impetuous for livestock producers to purchase vehicles dependent on fossil fuels. During the socialist era, rural livestock collectives provided transport for household movements and transfer of primary off-take products to urban distribution centers and value-added processing centers. Lack of cash and access to fuel are limiting factors retarding dependence of the livestock production system on fossil fuels.

Table 1. (Cont.)

Industrial Economy	Natural Economy	Mongolian Livestock Economy	Change Factors
Livestock production in the industrial economy favors large centralized production facilities (single livestock type and breed, feedlots, slaughterhouses, trading centers, etc.), which lead to biological and technological monocultures.	Livestock production in the natural economy favors dispersed production among small units.	Although livestock production is relatively dispersed, the trend is towards concentration of animals because of social and economic reasons	Concentration of animals introduces density-dependent feedback mechanisms. Unless more top-down interventions are added to the livestock production system, sustainability of livestock production and ecosystem stability can rapidly be negatively impacted.
Livestock production in the industrial economy is linear and extractive, emphasizing production.	Livestock production in the natural economy is circular and renewable, encouraging reproduction.	Most livestock production in Mongolia continues to be circular and renewable. An emphasis on production is developing in some areas (e.g., change in herd structure to favor Cashmere goats because of market demand for Cashmere, introduction of Suffolk sheep because of potentially higher meat yields).	Changes will diminish adaptability of livestock in the Mongolian herd to environmental constraints; The demand for top-down intervention to support livestock with costly inputs will increase.
Livestock production in the industrial economy creates waste and fails to fully recycle resources.	Livestock production in the natural economy has no waste, everything is recycled	Generally, the Mongolian pastoral livestock production system has no waste. In some areas, economic and social changes are creating waste (e.g., little demand for yak hair, oversupply of Cashmere wool on the world market, little market demand for sheep wool).	Waste is a characteristic of an industrial economy usually generated by supply and demand functions of a market economy.
Livestock production in the industrial economy partitions natural resources into discrete economic spheres that operate independently of each other.	Livestock production in the natural economy views natural resources as a maze of connected habitats.	Pastoral livestock production has always viewed natural resources as habitats connected through space and time. Indigenous knowledge of the livestock herder allowed optimal use of accessible habitats. In areas where livestock are being concentrated for economic and social reason, the connectivity between humans, livestock and habitats is being lost.	Pastoral livestock production views natural resources as a "continuum" with forage and nutrients and shelter as the critical elements of livestock production. Livestock production in an industrial economy operates within artificially defined discrete units that have little relationship to the natural environment or animal behavior.

Mongolian Pastoral Economy

It appears reasonably certain that traditional pastoralism operated in a natural economy. Grazing areas were naturally defined except for boundaries imposed by "right of possession" by local groups of herders. Administrative or political boundaries existed (i.e., Mongolia was reported to be divided into four aimags instead of the current 21) but were designed to assist the natural livestock economy by allowing large-scale seasonal shifts between ecological regions to reduce environmental risk. The traditional pastoral livestock system was dependent on naturally produced animal feedstuffs and animal medicines (i.e., standing crop of forage, hay and supplemental animal feed produced in the local area by

the pastorlist and pastorlist produced indigenous veterinary medicines) in a natural solar energy system that focused on animal reproduction, self consumption, recycling and producing little if any waste in the production system. The pastorlist in the traditional livestock production system focused on using “indigenous knowledge” about climate and biophysical attributes of the environment gained over many generations to maintain optimal livestock production as a means to support pastoral livelihoods.

Nutrition in the form of macro and micronutrients is the most important part of the animal feeding equation in the pastoral production system. However, vegetation standing crop (usually expressed as yield or dry weight vegetation per unit area of land) is important since it is the primary source of nutrients in pastoral production systems. However, total amount of vegetation has little direct correlation with dietary intake or nutrient availability. Vegetation is often comprised of plant species that have foliage material: (1) unpalatable to the animal, (2) unavailable to the animal, (3) low nutrient availability, or (4) cause harm to the animal. Total amount of vegetation standing crop does not measure nutrients available to support grazing herbivores. Palatability of plants, consumable biomass of palatable plants, and availability of nutrients in the consumable biomass of palatable plant species over temporal and spatial continuums are measures of vegetation standing crop that are pertinent to the grazing animal in pastoral production systems.

In an industrial economy, humans attempt to classify vegetation into artificial units to gain insight and understanding of vegetation dynamics and animal impacts on vegetation. Artificial classifications such as plant species, range sites, plant communities, ecological condition, habitat type; ecological site, etc. only indirectly have significance to a grazing herbivore. Whereas change in plant species composition in an artificially classified plant community may be used by the plant ecologist to indicate secondary succession is occurring, the meaning to the grazing herbivore lies in the increase or decrease in nutrients available temporally and spatially. From the perspective of the human classifier, changes in ecological condition and carrying capacity may be occurring relative to the plant community that either have no impact on the grazing herbivore, a negative impact, or a positive impact. The perceived boundaries of a unit of vegetation standing crop from the perspective of a grazing herbivore are based on the animals integration of habitat attributes and internal driving forces which depend on the animal’s ability to see, feel, and remember sites and the animals internal needs (e.g., hunger, thirst, predator avoidance, thermoregulation, or social interaction) (Launchbaugh and Fredrickson 2000).

External control mechanisms reduce the opportunity for development of feedback control and persistence of the system depends upon other stabilizing mechanisms. Thus, in North American livestock production systems modified by the industrial economy, the emphasis of rangeland and animal management has been on rangeland improvements, rangeland rehabilitation, grazing systems and management designed to adapt behavior of less mobile, space limited (i.e., fenced in) livestock, artificially delimited pasture units, maintaining or improving ecological condition of artificially defined vegetation units, and emphasis on understanding grazing impacts on vegetation (Benke and Scoones 1992).

In a natural economy, vegetation standing crop is the focal point of interaction between the herder-producer, livestock and other grazing herbivores, and the biological and physical components of natural resources. However, as opposed to livestock production in an industrial economy, the emphasis of management is placed on trying to optimize animal body condition to maintain animal productivity at levels needed to obtain animal off-take surplus to needs of individual animals comprising the animal herd. Without this emphasis, or if externalities limit managerial response time and adversely influence decision-making processes, sustainability over time of both the livestock producer and the livestock herd is diminished.

To survive, the herder has to have: (1) both the personal household and livestock mobility needed to gain access to pastoral resources on a daily basis and at critical times in response to environmental conditions over which the herder has no control, (2) animals that are adapted to their environment relative to overcoming weather extremes and obtaining substance from the vegetation characteristic of their environment sufficient to ensure livelihoods of the livestock population and the dependent human population; (3) a flexibility in decision-making that allows the herder to respond to immediate needs in a continually changing environment while keeping a long term decision-making perspective to ensure that response options to both foreseen and unforeseen events affecting livestock production and personal livelihoods exist.

The pastorlist has to retain mobility in livestock production and be flexible in decision-making in an environment that varies consistently through time and space. If mobility and flexibility are not retained, environmental risk increases the probability that a catastrophic event will significantly reduce the production capability (i.e., either increase mortality or reduce reproductive efficiencies to levels that directly affect livelihood potential of the pastorlist themselves.

Optimal mobility in terms of livestock management means having the capability to move livestock away from a severe weather event, such as severe winter storms, summer drought, and infestations of pest species to an area where livestock have increased opportunities of survival. Optimal mobility also means having the type and kind of livestock that can utilize available pastoral resources effectively during different seasons and under different environmental conditions. Imposition of criteria that reduces or limits mobility of livestock and the producer, whether arising from internal or external sources, can destabilize or even destroy pastoral production systems.

Pastoral decision-making is based on knowledge of livestock behavior and needs and knowledge about the set of physical and biological resources available to satisfy daily, seasonal and annual needs of the livestock in the environment to which pastoralists have access. The pastorlist possessing ‘indigenous’ knowledge sufficient to increase the probability of making wise livestock management decisions in daily, seasonal, and multi-annual time frames will almost certainly have advantages over less knowledgeable pastoralists. However, mobility limitations reduce the effectiveness of employing

indigenous knowledge in animal management decision-making, even to the degree that all decisions are wrong and the pastorlist is only choosing the lesser evil.

F. Solutions to the "Commons" Problem

Mongolia as a country and people are in transition from a known past to an unknown future. Change that has occurred in Mongolia over the last century and change that is presently occurring cannot be denied or glossed over. Political, economic, and social institutions have obviously undergone radical change since 1990. The Mongolian political and socio-economic policies during the socialist era initiated large-scale movement of pastoral livestock production towards an industrial economy. Conversion of large areas of natural pasture to crop monocultures and using rural collectives to maximize livestock production, even though pastoral grazing strategies and management were retained, introduced an industrial economy to the livestock production system.

Livestock production in general, especially pastoral livestock production has been Mongolia's primary safety net for social and economic problems associated with the transition to market-based economy. More people are engaged in livestock production and more people are dependent on livestock production as a source of livelihood compared to the socialist era. Not only have livestock numbers increased (i.e., from approx. 25 million in 1993 to approx. 31 million in 1999) but they have increased in a vacuum relative to an effective policy, production or marketing infrastructure.

Impacts of an Industrial Economy

Changes to the pastoral livestock production system, which directly employs a quarter of the Mongolian population and provides food and fiber to the other three-quarters of the population, are obvious. The pastoral livestock production system is being forced to adapt to a new version of an industrial economy driven by market economics (as opposed to an industrial economy driven by "command" economics) while the means and techniques of production have reverted to a more traditional pastoral livestock production system. The infrastructure built during the collective era to support livestock production in a socialist industrial economy is rapidly disintegrating. A new support infrastructure and policies assisting adaptation of the livestock production system to new social and economic realities doesn't exist. As a result, livestock herders are adopting "self interest" and "self preservation" as the basis of decision-making in livestock production.

Actual livestock production continues to use production practices characteristic of livestock production in a natural economy but forces external to actual livestock production are forcing the production system to behave as it would in an industrial economy. The large increase in livestock numbers and changing demographics of the livestock population is causing animal density-dependent relationships to become major influences affecting sustainable use of natural resources. Conflict over access to resources is increasing as more and more people either want to obtain a share of a finite set of

resources or those who have access to the finite set of resources try to maintain their advantage.

It is apparent that the Mongolian pastoral livestock production system is assuming traits more characteristic of livestock production in an industrial economy rather than livestock production as part of a natural economy. These traits include: (1) large increases in livestock numbers in certain regions and by individuals producers, (2) movement of herders and livestock towards potential markets for livestock off-take products, (3) changes in herd structure to favor animals and animal products (i.e., Cashmere goats or milking mare herds) for which a cash market exists, (4) control of large numbers of livestock by a few producers while many producers have access to only a few animals, (5) increasing conflict between individual producers over control and access to critical resources, (6) less mobility in the production system as producers seek to gain "de facto" control of critical resources through "right of possession,"(7) less flexibility in production decision-making as the collective infrastructure and co-resource use agreements made between producer groups to reduce environmental risk (i.e., storing standing crop forage on set-aside winter range to allow use during severe weather related events,), (7) government acceptance of externally generated policies oriented towards prohibition of livestock use on areas (i.e., National Parks, wildlife reserves, etc.),

Market Factors

Highest concentration of the Mongolian human population (approximately one quarter) occurs in the capital city, Ulaanbaatar, and three other cities. The four urban areas have considerable demand for meat and milk and market places have been established to meet the demand. In rural areas (most of Mongolia is a rural area), the provincial (*aimag*) and county (*sum*) centers have relatively high concentration of people, many of whom are unemployed and have some livestock to support their livelihood. Provincial and county centers are also developing as market places for surplus meat and milk, hides, and fiber produced by more solvent households engaged in more traditional pastoral livestock production. Purchase of animal hides and fiber by traders to supply value-added processing facilities located in the urban areas or the export market occurs at the provincial and county centers. Although live animals may be purchased at provincial and county centers, most exchange of live animals is by direct treaty between buyer-traders and the livestock producer. Market economics appear to be a major factor causing change in producer and livestock demographics whereby livestock are becoming concentrated and density-dependent factors increasingly drive the both livestock production and vegetation resources.

Poverty Factors

Poverty among the rural population is a factor causing concentration of livestock and change in the kind of livestock production system possible. In rural areas where livestock production is the only on-going economic and social activity, poverty can be defined by whether households have sufficient livestock to provide for their consumptive needs either

directly or through sale or barter of off-take products and whether households can access natural resources sufficient to maintain the livestock in their possession. Consequently, poverty households are those without livestock and alternative income sources, households with livestock numbers below minimums needed to sustain livelihoods, or households with sufficient livestock but insufficient access to natural resources needed to sustain livestock at a level sufficient to produce a consumable and marketable surplus. Poverty households seeking access to nominally free resources are increasingly coming into conflict with livestock producers who have "de facto" control of resources needed for optimal and sustainable livestock production.

Infrastructure Collapse

Another factor influencing change in the kind of livestock production system results from an almost complete breakdown in a relatively short time period of the infrastructure built to support collective and state farm livestock production. Dissolution of the highly organized and vertically integrated livestock production system; inequitable and often irrational dispersion and privatization of livestock and other collective assets, and abnegation of responsibility by the government to assist adaptation of livestock production to new externalities have created an "authority vacuum" that influence actions of individual households or small groups of associated households (*Khotil*) to act solely in their "own interests." In effect, livestock producers are beginning to respond similar to livestock producers in an industrial economy governed by market economics.

G. Conclusions

Imparting sustainability to livestock production on the pastoral commons of Mongolia under current conditions requires that intervention be focused on the critical link between the needs and activities of a functioning pastoral livestock production system and the diverse needs and activities of a Mongolia in transition Political and socio-economic conditions in Mongolia no longer favor low surplus but sustainable livestock production. For better or worse, livestock production is assuming (or is being forced to assume) characteristics consistent with natural resource use and economic production activities in an industrial economy. Consequently, livestock production systems other than pastoral systems are developing. Realizing that livestock production is occurring based on a number of models that use resources differently and have different needs is important if interventions to support rural poverty alleviation, infrastructure development, supportive policies, and sustainability of resource use are initiated.

Finding and applying solutions to issues that are increasingly affecting sustainability of the Mongolian pastoral livestock production system requires two directions of approach. One approach has to be a "top-down" approach since the political and socio-economic environment in which an increasing number of livestock herders operate is not a pure natural economy. A primary criterion guiding the "top down" approach is developing and applying appropriate resource use guidelines to mitigate or alleviate the adverse impacts associated with concentration of livestock. In areas where non-pastoral livestock

production systems are developing, animal production is subject to density-dependent feedback mechanisms characteristic of an equilibrium environment.

The other direction has to be a “bottom-up” approach because livestock production generally throughout Mongolia continues to use pastoral grazing management strategies as the basis of livestock production. Primary criteria guiding the bottom-up approach to finding solutions should be “don’t impose or encourage any programs that reduce or curtail mobility of livestock or decrease flexible decision-making by the livestock herder. Conversely, programs that reduce the number of people engaged in livestock production or lead to a more rapid turnover in livestock need to be encouraged. Supporting development of the infrastructure needed to build rural value-added processing facilities for livestock off-take products could potentially improve incomes of rural poor as well as reduce livestock numbers close to population centers. Other local industries, such as transport and feed supplements, could be developed to support pastoral livestock production and poverty alleviation.

Key Elements of Sustainable Livestock Production

A key element in developing a sustainable livestock production system for the pastoral commons of Mongolia is retaining pastoral grazing and management strategies based on animal mobility and flexible decision-making. By doing so, the pastoral production system is not forced to operate subject to “density-dependent functions.” Dividing the natural resource base into artificial units for the purpose of allocating natural resources to individual livestock herding entities is detrimental to sustainable pastoral livestock production. Grazing “efficiencies” obtained from pastoral grazing management strategies are lost. Animal mobility and decision-making flexibility that are continually needed by the livestock producer to reduce environmental risk will be lost

Livestock herders need group empowerment to exert control over local natural resources needed for livestock production. Empowerment to individuals, as is generally the case in a market based industrial economy and as is beginning to occur in Mongolia as “de facto” control of livestock production resources continues to develop, decreases livestock mobility and flexibility needed in livestock management decision-making for livestock producers as a whole. Group empowerment does not mean reestablishing rural livestock collectives, rather it means developing local livestock or grazing associations with membership limited to livestock producers using local and naturally defined natural resources that have customary rights to use those resources. Local group empowerment in the form of “quasi-legal” institutions such as livestock and grazing associations will allow the livestock herder to interact with external institutions (i.e., government, markets, transport, traders, etc.) at the point in the production chain where livestock production, livestock herder, and resource use occur. Interactions between local group empowerment organizations and entities external to the livestock production system at the point of production usually are more beneficial to the livestock producer than if the livestock herder is excluded and can only react to externalities.

Although different models of livestock production are developing in Mongolia, most livestock production remains dependent on forage produced annually on natural pasture ecosystems. Interventions for the purpose of improving the economic sustainability of livestock production and the ecological sustainability of natural resources used in livestock production should focus on improving nutrients available to livestock during annual production cycles. As described earlier, nutrients are the critical need of livestock and the key element of successful pastoral livestock production.

Maintaining or restoring ecological condition of natural pasture ecosystems (or habitat) is a focus of environmental organizations and mainstream rangeland ecologists in western North America. Animal carrying capacity, range site ecological condition guides, fixed stocking rates, regulating time of grazing and number of animals, and other regulatory/improvement mechanisms address livestock grazing impacts determined by density-dependent feedback. Although this type of intervention is detrimental to a properly functioning pastoral livestock production system, interventions of this nature may be needed to improve sustainability of natural resources used in livestock production models developing as a response to on-going socio-political and economic changes (Sheehy 1992, Sheehy 1993).

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