TIBET

ENVIRONMENTAL ANALYSIS

Background paper in preparation for USAID's program

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"Tibet is also known as Xizang, the Western Treasure House. The treasure is not gold or other such wealth, but the land in all its beauty, the mountains and turquoise lakes, the rhododendrons, Tibetan antelopes and the thousands of other species. The wealth of Tibet and the happiness of its people ultimately depend on the health of the land with all of its biologically diversity."

George Schaller (2000)

1. INTRODUCTION

Section 119 of the Foreign Assistance Act requires that all country plans include an "analysis of (1) the actions necessary in that country to conserve biodiversity, and (2) the extent to which the actions proposed for support by USAID meet the needs thus identified."

China is a USAID non-presence country and this paper does not seek to give a comprehensive assessment of China's biodiversity, threats, and needs. There have been a number of thorough biodiversity assessments by various groups, including the Government of China, the World Bank, WWF, and others. The broader subject of the environment in Western China has also been included in a number of recent reports by the World Bank and the Asian Development Bank. This paper analyses environmental and biodiversity issues in the Tibetan plateau of China and their linkages to USAID development objectives in Tibetan communities in China. Most of the Tibetan plateau consists of rangeland, one of the largest such ecosystems in the world. As such, this paper focuses on the Tibetan rangeland environment; vast landscapes that have been sorely neglected in the past.

With an area about four times as big as Texas, the natural environment of the Tibetan plateau is of global significance, as well as a basis for the private sector growth that can provide improved livelihoods for Tibetan people. With a range of ecosystems, small population scattered across a large land mass, limited infrastructure and harsh climate, the Tibetan plateau faces major development challenges. Can the Tibetan region of China, now fairly open to the world after centuries of isolation, achieve a sustainable development path that builds on it most significant physical assets – its large territory, natural resources, and unique assemblage of ecosystems and biodiversity – to provide a better life for the people and civilization that have evolved from its environment? Or is the Tibetan region destined to follow the path of many other regions of China and numerous other transition and developing countries -- a path of rapid resource exploitation that undermines the very resources that provide a potential basis for long-term economic growth? How the environment is factored into development in the Tibetan plateau as well as more broadly into China's development is central to future aspirations of people living in the region as well as to USAID objectives for assistance to Tibetan communities in China.

The Tibetan plateau is highly reliant on the environment for its economy. More than most other regions of China, it has managed to maintain more of a balance between using the land for sustenance and over-exploiting it. However, in the last two decades, economic development has increased pressures on the environment. Much of the environment of the Tibetan plateau is relatively unspoiled, but there is increasing concern over rangeland and forest degradation, loss of biodiversity, and environmental pollution. The Tibetan plateau is also a very harsh and fragile landscape where environmental rehabilitation is difficult and a slow process. Widespread poverty, lack of value-added manufacturing and reliance on primary product for employment, labor and exports, and the reliance on funding from the central government in Beijing create alarming pressure to overexploit natural resources. There is growing environmental concern over a number of large development projects on the Tibetan plateau, such as the 1,142 km long Golmud-Lhasa railway, hydropower projects on the Yarlung Tsangpo River, and water transfer projects that will transport water from the Yangtze River to the Yellow River.

The Government of China has placed high priority development of the Tibetan plateau. This is evident in the Western Development Strategy which emphasizes two main objectives: (i) to reduce economic disparities between the western and other regions: and (ii) to ensure sustainable natural resources management. In addition, while sustainable growth in agriculture and ensuring food security was one of the five key areas of China's development strategy articulated in the Ninth Five Year Plan, in the 10th Five Year Plan, there has been a shift in the focus away from increased quantities of agricultural products towards improved quality and more ecologically sound types of production. Thus, China appears committed to reverse the land degradation trends the country is experiencing, including on the Tibetan plateau. However, it is confronting major difficulties in dealing with the simultaneous short and long-term trade offs, such as improving the welfare of the people living in the western regions and protecting and maintaining the numerous economic and environmental benefits provided by the natural resources.

Factors such as geographical extent, watershed protection, biodiversity conservation, livestock production and economic development suggest that the Tibetan plateau should be a priority area for development, but unfortunately it has not been given the consideration it is due. The Tibetan plateau is home to millions of poor farmers and herders who have largely been ignored by previous development efforts due to remoteness and as a result of government policies that failed to appreciate the importance and potential of the extensive rangeland environment on the plateau. The lack of concern for the Tibetan plateau and misconceptions regarding the indigenous agricultural and pastoral production systems have led to a general downward spiral in the productivity of many areas, loss of biodiversity, and increased marginalization of Tibetan herders and farmers. Reversing these trends should become a priority for those concerned about the future development of Tibetan communities in China. The challenge for the future is to balance the diverse economic, cultural and social needs of the Tibetan people with the need to maintain the environment and conserve the biodiversity and cultural heritage of the Tibetan plateau. Because of its importance to the international community, a much better job needs to be done of managing the Tibetan plateau environment for cultural, social, economic and ecological sustainability.

2. ENVIRONMENTAL STATUS, TRENDS, AND THREATS

2.1. Status of natural resources

Encompassing an area of 2.5 million sq. km, about one-quarter of China's total land area, the Tibetan region stretches for almost 1500 km north to south and about 3000 km from east to west. The Tibetan plateau includes all of the Tibetan Autonomous Region (TAR) and Qinghai Province, northwest Yunnan Province, western Sichuan Province, southwestern Gansu Province, and the northern flanks of the Kunlun Mountains in southern Xinjiang Autonomous Region. The Tibetan plateau is the largest plateau on earth, an uplift that is almost a third of the size of the continental USA. Over 80 percent of the plateau is above 3000 m in elevation, and about half is over 4500 m. The Tibetan plateau is a complex landscape. It consists of several distinct topographic regions determined by drainage patterns and the parallel mountain ranges that divide it. Only the eastern and southern parts of the Tibetan plateau have outlets to the ocean. In the east, the upper reaches of the Yellow, Yangtze, Mekong and Salween Rivers are located, and in the south and southwest the Yarlung Tsangpo (which becomes the Brahmaputra in India), Indus, Ganges, and Sutlej are found. Much of the Tibetan plateau is comprised of large lake basins that have no outlets and are ringed by mountains. Unlike the extensive, open steppes of most of Eurasia, the Tibetan plateau is cleaved by rugged, snow-capped mountain ranges, deep river valleys, and extensive lake basins which give rise to varying topography, climatic conditions, and vegetation types.

Most of the plateau has a severe continental climate, but precipitation and temperature are strongly assocociated with longitude, latitude and elevation. The climate of the plateau can be divided into four categories. In the southeast it is a humid tropical and subtropical montane area. The low-lying fringe of the plateau is temperate, with the eastern part in Sichuan humid, the southern part in Tibet semiarid, and the north and west in Qinghai and Tibet arid. The central part of the plateau is subfrigid. The northern part of the plateau is frigid and arid.

Vegetation of the plateau is greatly influenced by factors such as precipitation, temperature, and wind, as well as topography and elevation. The plateau consists mainly of rangeland, one of the largest such ecosystems in the world and one that is floristically distinctive. About two-thirds of the total area of the plateau, 165 million ha, is classified as rangeland, which is 42 % of China's total rangeland area. Rangelands cover 70% of the Tibetan Autonomous Region (table 1). The rangelands are very diverse in structure and composition and vary from cold deserts in the west to alpine steppe, found in a broad band across the central plateau, and lush alpine meadows in the east.

Less than 10% of the Tibetan plateau is forested. Forests are limited to the eastern edge of the Tibetan plateau in Western Sichuan, northwestern Yunnan, southeastern Qinghai and eastern Tibet and in some valleys on the northern slopes of the Himalaya in Tibet. Only about 1% of the total area of the Tibetan plateau is cultivated, although the amount of land under agriculture in the northeast, and especially in the Qaidam Basin in Qinghai Province, has expanded in recent decades. In the eastern part of the plateau, crop land is concentrated in the lower valleys; in western Tibet along the valley and tributaries of the

Yarlung Tsangpo. The upper limit of cultivation is as low as 3300 m in some parts of the eastern plateau, but can reach 4400 m in western Tibet. The major crops are barley, wheat, peas, rape and potatoes.

Table 1. Land use on the Tibetan Plateau (in percentages)

	Rangeland	Forest	Cultivated land	Other
Tibet	69.1	5.1	0.2	25.6
Qinghai	56.1	0.3	0.9	42.8
Western Sichuan	44.4	10.6	0.7	44.3

Source: After Schaller 2001.

Vegetation on the Tibetan plateau plays a very important role in global climate change. Recent studies indicate that rangelands might be responsible for a substantial proportion of total terrestrial carbon production and that grassland biomes could constitute a significant sink of global carbon. The vast area and wide distribution of rangelands on the Tibetan plateau suggests that they could have widespread effects on regional climate and global carbon cycles. In spite of the relatively low biomass of much of the Tibetan rangelands, they are able to store considerable quantities of carbon both above and below ground. Alpine meadow and alpine steppe range, found primarily on the Tibetan plateau, comprise 40 percent of all carbon stored on China's rangelands, indicating that these ecosystems have a significant and long-lived effect on global carbon cycles.

The Tibetan plateau environment is also important because of its water resources. The plateau forms the headwaters' environment for many of the major rivers of Asia. The preservation and management of these river source environments have global implications, as the water from their watersheds will be of increasing importance in the future. Upsetting the ecological balance in these high-elevation rangelands will have a profound effect on millions of people living downstream. It is estimated that the rivers flowing off the Tibetan plateau sustain 47% of the world's population. As such, the Tibetan plateau demands greater respect and increased attention.

2.2. Biological importance

Situated at the confluence of five major biogeographical subregions – the Mediterranean and Siberian of the Palaearctic realm and the West Chinese, Indochinese, and Indian subregions of the Oriental realm, the Tibetan plateau is rich in biodiversity. The Tibetan plateau is one of the most biologically important and outstanding examples of the earth's diverse habitats and contains one of the last notable examples on earth of a rangeland ecosystem largely unchanged by man. In terms of biodiversity, the Tibetan plateau is both regionally and globally important as the plateau includes large, relatively intact examples of major ecosystems that in turn support numerous endangered species.

Over 12,000 species of 1,500 genera of vascular plants have been identified on the Tibetan plateau; accounting for over half of the total plant genera found in China. In the Tibetan Autonomous Region alone 9,600 species of plants have been recorded. There are 400 species of rhododendron on the Tibetan plateau, which make up about 50% of the

world's total rhododendron species. There are over 2,000 plants of medicinal value, which are of immense value and potential to medical science.

The animal world is also extremely rich. There are 210 species of mammals in 29 families; endemic animals are abundant including 40 endemic animals, 60 percent of China's total. There are 28 endemic birds, 2 endemic reptiles and 10 endemic amphibians. The Tibetan plateau has 115 species of fish. The endemic animal species of the plateau mainly consist of species found in the wetter, forested regions of the eastern and southern plateau and the alpine steppe in the west. Important animals include giant panda, red panda, golden monkey, takin, musk deer, and various species of birds such as Tibetan eared pheasant, monal and tragopan. Endemic species found in the alpine steppe include snow leopard, argali, Tibetan antelope, Tibetan gazelle, wild yak, wild ass, Tibetan wooly hare and birds like black-necked crane, Tibetan snowcock and Tibetan sandgrouse. There are 537 bird species in 57 families found on the plateau, with 37 of them classified as endangered.

The distribution of plant and animal species on the plateau is extremely uneven due to differences in topography and climate. For example, the Chang Tang region in the northwest occupies a quarter of the land area of the plateau, but hosts only one-tenth of the total species found on the plateau. The Himalayan and Hengduan Mountain region in the south and east comprise less than one-fifth of the plateau, but are home to over 80% of the total species found on the plateau.

2.3. Ecoregions of the Tibetan Plateau

Strategically focusing biodiversity conservation planning on the Tibetan plateau is hindered by the absence of maps with sufficient biogeographic resolution to accurately reflect the complex distribution of the varied ecosystems. Recently, a system of land classification based on the ecoregion concept (Box 1) has gained popularity among conservation biologists and ecologists as a tool for conservation planning.

Box 1. What is an Ecoregion?

Ecoregions are relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use changes. Ecoregions share a large majority of their species, ecological dynamics and environmental conditions and are defined by climate, landforms and native species. Ecoregions are large enough to encompass natural processes and to capture ecological and genetic variation in biodiversity across a full range of environmental gradients. Ecoregions reflect the distribution of species and communities more accurately than do units based on vegetation structure or from remote-sensing data and can highlight those areas that are most distinctive or have high representation value and are therefore worthy of greater attention. Conservation strategies that consider biogeographic units at the scale of ecoregions are ideal for protecting a full range of representative sites, conserving special elements, and ensuring the persistence of populations and ecological processes.

Source: Olson et al. (2001)

Ecoregion maps offer features that enhance their utility for conservation planning at global and regional scales: comprehensive coverage, a classification framework that builds on existing biogeographic knowledge, and a detailed level of biogeographic resolution. Ecoregion maps can be used as a biogeographic framework to highlight those areas of the world that are most distinctive or have high representation value and are therefore worthy of greater attention. Ecoregions are ranked by the distinctiveness of their biodiversity features – species endemism, the rarity of higher taxa, species richness, unusual ecological or evolutionary phenomena, and a global rarity of their habitat type. Ecoregions can also be ranked by threats to biodiversity, the status of their natural habitats and species, and degree of protection. New ways of assessing biodiversity loss and global threats – from climate change to logging, and overgrazing – are facilitated by this detailed map of ecoregions. Ecoregion maps can also be a strategic tool to determine conservation investments. Conservation strategies that consider biogeographic units at the scale of ecoregions are ideal for protecting a full range of representative sites, conserving special elements, and ensuring the persistence of populations and ecological processes. The world has been divided into 14 biomes and eight biogeographic realms and within these are 867 ecoregions. For the Tibetan plateau, 15 different ecoregions have been identified (table 2).

Table 2. Ecoregions of the Tibetan Plateau and Their Extent

Ecoregion	**Area (km2)**	**% of total area**
Central Tibetan Plateau alpine steppe	629,500	23.13
Southeast Tibet alpine shrub and meadows	460,800	16.93
Northern Tibet – Kunlun Mountains desert	374,400	13.76
Tibetan Plateau alpine shrub and meadows	272,100	9.99
Qaidam Basin semi-desert	192,000	7.05
Western Tibetan Plateau alpine steppe	143,300	5.27
Eastern Himalayan alpine shrub and meadow	121,200	4.45
Hengduan Mountains subalpine conifer forests	99,400	3.66
Mekong – Yangtze Gorge conifer forests	82,800	3.04
Qionglai – Minshan conifer forests	80,200	2.95
Qilian Mountains subalpine meadows	73,200	2.69
Western Himalayan alpine shrub and meadows	70,200	2.58
Yarlung Zangpo Valley arid steppe	59,500	2.18
Northeast Himalayan subalpine conifer forests	46,300	1.70
Qilian Mountains conifer forests	16,700	0.61
Total	2,721,600	

Source: Olson et al. 2001.

Note: The area of each ecoregion includes the entire area, including non-vegetated areas on mountains, rivers, lakes, etc. Some of the ecoregions extend into Nepal and India, making a total of 2.7 million km2, while the Tibetan Plateau in China proper is considered to only encompass 2.5 million km2.

A number of biological regions on the Tibetan plateau display highly distinctive species, ecological processes, and evolutionary phenomena and are now recognized as habitats of global importance for conservation of biological diversity (Box 2). These regions have

been determined to be some of the richest, rarest, and most biological important and outstanding examples of the Earth's diverse habitats and are included in WWF's recent Global 200 ecoregion priority setting exercise[1]. The inclusion of these areas on the Tibetan plateau in the Global 200 list highlights the special attention these areas require for conserving representative examples of the world's biodiversity.

Box 2. Globally Significant Ecosystems on the Tibetan Plateau

The *Tibetan Steppe* is situated on the Tibetan plateau in Tibet, Qinghai, and Gansu and encompasses 1.5 million sq. km, slightly larger than Alaska. The Tibetan Steppe includes the most intact example of montane rangelands in Eurasia with a relatively intact vertebrate fauna, and is also one of the largest remaining terrestrial wilderness areas left in the world. The Tibetan Steppe ecoregion supports numerous rare and endangered wildlife species such as the Tibetan wild yak, Tibetan wild ass, Tibetan antelope, Przewalski's gazelle, argali, white-lipped deer, snow leopard, Tibetan sand fox, wolf, and brown bear. Despite low human population density, hunting and livestock grazing threaten natural habitats and biodiversity.

The *Eastern Himalayan Alpine Meadows* is located in eastern Tibet and northwest Yunnan and in neighboring regions of Nepal, Bhutan and India and comprises 121,000 km2, about the size of Mississippi. Due to its position at the juncture of the Palearctic and Oriental zoogeographic zones, this region is one of the most ecologically diverse alpine communities on Earth. Many species of plants and animals are not found elsewhere. There are 7,000 species of plants in the ecoregion, which is triple the number in other alpine regions in the Himalaya. Population growth and increased tourism have put pressure on remaining wild areas in the ecoregion and biodiversity is also threatened by hydropower development.

The *Eastern Himalayan Broadleaf and Conifer Forests* is found in eastern Tibet and northwest Yunnan and adjoining areas of Nepal, Bhutan, India and Myanmar and encompasses 170,000 km2, or about the size of the state of Washington. The forests of this region are some of the most biologically diverse forest ecosystems found anywhere in the world and include temperate rain forests with numerous species of rhododendron and conifer forests of spruce, fir, and larch. The forests also provide habitat for numerous species of wildlife and birds. Logging and livestock grazing has resulted in forest degradation and loss of wildlife habitat.

The *Southwest China Temperate Forests* is located in Gansu, Sichuan and Yunnan Provinces and encompasses 262,446 km2, a little larger than Colorado. The rich temperate forests are home to many endemic species, including a number of ancient groups of plants and animals. Like many areas of high biological diversity, much of this region escaped glaciations during past Ice Ages, making it a refuge for many species. Ancient plants include the dawn redwood, Chinese yew, Chinese cedar and ginkgo tree. Animals include the giant panda, red panda, Chinese stump-tailed macaque, Asiatic black bears, golden takin, and tufted deer. Growing population in the region has increased demand for agricultural land and timber products, leading to degradation of forests and loss of wildlife habitat. Unplanned tourism development is also now threatening the region.

Source: Adapted from WWF (2000)

Note: The ecoregion mapping exercise complements global priority-setting analyses, such as the Global 200, by providing a finer level of resolution to assess biodiversity. For example, Global 200's Tibetan Steppe amalgamates the following ecoregions: Central Tibetan Plateau Alpine Steppe, Tibetan Plateau Alpine Shrublands and Meadows and the North Tibetan Plateau – Kunlun Mountains Alpine Desert.

[1] The Global 200 is a science-based global ranking of the Earth's most biologically outstanding terrestrial, freshwater and marine habitats. It provides a critical blueprint for biodiversity conservation at a global scale. The aim of the Global 200 analysis is to ensure that the full range of ecosystems is represented within regional conservation and development strategies, so that conservation efforts around the world contribute to a global biodiversity strategy. By focusing on large, biologically distinct area, the Global 200 sets the stage for conserving biodiversity on the broadest scale at which natural systems operate.

2.4. Rangelands

Rangelands cover about 70% of the Tibetan plateau and include grasslands, steppes, deserts, alpine meadows and shrublands and forest areas used by grazing animals. Encompassing an area slightly larger than the country of Mongolia (1.7 million sq. km), the grazingland of the Tibetan plateau is one of the world's largest rangeland landscapes. Covering a vast region with diverse topography and climate, the rangelands of the Tibetan plateau are extremely varied, ranging from lush alpine meadows and alpine steppe to semi-arid steppe and cold desert. Each different range type as its own unique assemblage of plants and animals. Rangelands support diverse mammalian faunas, including the smallest (insectivores) and largest (ungulates) vertebrates. Many medicinal plants are also found in the rangelands and are of increasing economic importance.

Schaller (1998) divided the rangelands of the plateau into six major regions: (i) the alpine meadows in the east; (ii) arid shrubland and steppe in the valley of the Yarlung Tsangpo and Indus River in southern Tibet; (iii) alpine steppe in the central part of the plateau; (iv) cold desert in the northwest; (v) temperate desert in the southwest; and (vi) the Qaidam Basin desert. In the 1990s, Chinese scientists prepared atlases and maps of rangeland resources that classified all of the rangeland in China into 17 different types, based on climatic zonation, humidity index, and vegetation type. The most important rangeland types on the Tibetan plateau are alpine meadow, covering 45% of the total area; alpine steppe, comprising 29%; alpine desert steppe, with 6%, temperate meadow, with 4%, alpine desert with 4%, and alpine meadow steppe with 4% (table 3).

In the rangelands of the Tibetan plateau, an unprecedented loss of habitat and biodiversity has taken place in the last 40 years. With each species lost, a part of the Earth's genetic heritage disappears forever. The innumerable species, both plant and animal, that make up the biological diversity of the Tibetan rangelands, construct an intricate life support system upon which millions of people rely. The rangelands and the biological resources found in them play a critical role in the region's overall economic development and people's well being. Tibetan nomads and farmers rely directly on plants, water, animals, and other natural resources found in the rangelands for their livelihoods. Other people, both those residing in rangeland environments and in adjacent areas, are also directly or indirectly dependent on rangeland resources. Rangeland degradation and habitat loss can no longer be regarded solely as localized problems since the implications are more widespread, affecting national, regional, and international interests.

There has been a considerable reduction in the number, variety, and range of wild animals, especially large ungulates, on the rangelands of the Tibetan plateau. The decline of wildlife was particularly sharp during the Great Leap Forward (1958-1960) when many wild ungulates were slaughtered for food and during the Cultural Revolution (1968-1978) when conservation directives were ignored. With respect to biodiversity conservation, the rangelands of the Tibetan plateau have largely been neglected in the past. The lack of concern for these grazing land ecosystems and misconceptions regarding their functioning and use have led to a general downward spiral in the productivity of many areas and loss of biodiversity.

Table 3. Rangeland Types of the Tibetan Plateau.

Rangeland Type	Forage yield (kg/DM/ha)	Area (1,000 ha)	Percent of total area
Temperate meadow-steppe	1465	210	0.16
Temperate steppe	889	3,833	2.92
Temperate desert-steppe	455	968	0.74
Alpine meadow-steppe	307	5,626	4.28
Alpine steppe	284	37,762	28.75
Alpine desert-steppe	195	8,679	6.61
Temperate steppe-desert	465	107	0.08
Temperate desert	329	2,084	1.59
Alpine desert	117	5,967	4.54
Tropical tussock	264	9	--
Tropical shrub tussock	2527	28	0.02
Temperate tussock	1643	1	--
Temperate shrub tussock	1769	140	0.10
Lowland meadow	1730	1,168	0.88
Temperate mountain meadow	1648	6,067	4.61
Alpine meadow	882	58,652	44.64
Marsh	2183	21	0.01
Total		131,322	99.93

Source: Adapted from Chen and Fischer, 1998.

Note: The area included in Table 3 includes all of the Tibetan Autonomous Region, Qinghai, western Sichuan and northwestern Yunnan Provinces. It does not include the Tibetan Steppe region found in Gansu and Xinjiang, which encompasses an estimated 25 million ha. An additional unclassified 933,000 ha of rangeland in central Tibetan Autonomous Region is also not included in the total area. Together, this adds up to 157.2 million ha.

When considering biodiversity in Tibetan rangelands, one usually thinks of flowering plants and wild animals, yet an important aspect of biological diversity is also the domestic livestock species that are found in rangelands. These animals have evolved over centuries and are adapted to the wide range of environmental conditions found in the rangelands. They exhibit numerous, unique adaptive traits and resistance to diseases, which has enabled man to exploit the rangeland resources. The yak, for example, is one of the most important domestic animals for Tibetans. Without the yak, it is doubtful if man could survive on the Tibetan plateau. As such the conservation and management of yak genetic diversity are essential for sustainable pastoral development over a large geographic area.

The genetic diversity of the wild and domesticated plants and animals found in the rangelands is a valuable resource. Most of the food that mankind consumes comes from wild and domesticated species of plants and animals. The wildlife found on the Tibetan plateau includes the wild relatives of domestic animals that have fundamentally changed human civilization. The wild yak, for example, is the progenitor of all domestic yak

populations. There is little doubt that the presence of wild yaks, and their later domestication, was the single most important factor in the adaptation of civilization on the Tibetan plateau. The genetic pool of species found in the rangelands may hold important keys for improving livestock, developing new crop varieties, curing disease, and numerous other benefits to mankind as yet undiscovered. Certain traits found in indigenous livestock breeds may be beneficial in increasing productivity of improved livestock also.

The rangelands in many areas continue to support a variety of wild ungulates and, in the remote and uninhabited areas of the Tibetan plateau, unique upland fauna such as the Tibetan antelope, wild ass, and wild yak survive in moderate abundance. In addition to the wild ungulates, there are numerous species of small mammals, birds, and predators that are important components of the rangeland ecosystems. The rangelands of the Tibetan plateau that have previously been the domain of nomadic pastoralists are increasingly coming into focus as important areas for biodiversity. Their inaccessibility has permitted the survival of species eliminated in many other areas. For example, the recently established Chang Tang Wildlife Reserve in Tibet now provides protection for a number of wild ungulates and the rangeland landscape they inhabit (Box 3).

Box 3. Biodiversity of the Chang Tang Wildlife Reserve, Tibet

The Chang Tang Wildlife Reserve of Tibet, encompassing about 300,000 square kilometers, includes one of the last, largely undisturbed rangeland ecosystems in the world and provides habitat for numerous wildlife species, several of which are endangered and endemic to the Tibetan plateau. Rangelands in this Reserve can be categorized into three major types: alpine steppe, desert steppe, and alpine meadow. Rangelands are spatially heterogeneous ranging from patch to landscape scales in composition and productivity. Although limited in overall plant species' richness, the rangelands are nevertheless diverse and provide habitat for six wild ungulate species, as well as a variety of birds, small mammals, and large predators including the snow leopard and Tibetan brown bear. The six wild ungulates include: *chiru* or Tibetan antelope, Tibetan gazelle, Tibetan argali, blue sheep, the *kiang* or Tibetan wild ass, and wild yak. Tibetan gazelle are selective feeders, concentrating on forbs. Tibetan antelope, blue sheep, and argali are mixed feeders, consuming both graminoids and forbs while the wild yak and Tibetan wild ass consume mainly grasses and sedges. The Chang Tang is coming under increasing pressure from nomads and their livestock; illegal hunting, especially of Tibetan antelope; and the threat of oil-drilling and gold mining. Despite these pressures, the rangelands can continue to provide habitats for wildlife as well as grazing for livestock if properly managed. This will require innovative management plans that take into account the needs of wildlife as well as the needs of Tibetan herders and their livestock.

There are numerous species of wildlife found in the Tibetan rangeland ecosystems that are of global and national significance. Some charismatic species such as the snow leopard are also fairly well known. Other species, however, such as the wild yak, Tibetan antelope, or *chiru*, and Tibetan wild ass, or *kyang*, little is known about but they are vital components of the Tibetan rangeland ecosystems. Schaller (1998:125) noted that the wild yak, probably more than any other animal symbolizes the plight of wildlife on the Tibetan plateau (Box 4). The black-necked crane is another species of great cultural importance to Tibetan people and innovative attempts to conserve crane habitat could

provide a model for wildlife conservation in agricultural areas (Box 5). The Tibetan antelope is another charismatic species that, being migratory, defines the vastness of the Tibetan wilderness (Box 6).

Box 4. The Wild Yak: A Keystone Species of the Tibetan Rangelands

Wild yaks characterize the rugged wilderness of the Tibetan rangeland ecosystem. No other animal so evokes the raw energy and wild beauty of the Tibetan landscape. Standing almost two meters tall, wild yak bulls can weigh up to a ton. Their horns, which can be a meter long, are still used as milk pails by Tibetan nomads. Wild yaks are magnificent animals. Their long hair hangs like curtains, almost sweeping the ground, and makes them appear even more massive than they actually are. Female wild yaks and their young congregate in large herds, sometimes made up of one hundred or more animals, while most bulls are solitary or live in small bachelor herds. The wild yak is a totem animal of the Tibetan wilderness and achieved mythic status long ago in Tibetan life. Superbly adapted to the rugged conditions of the highest plateau on earth, wild yaks are a keystone species: their presence identifies one of the last, great, unspoiled ecosystems of Central Asia.

Wild yaks once roamed throughout the Tibetan Plateau and numbered in the millions. Now, only an estimated 14,000 wild yaks are left, and these animals can only be found in the most remote areas, far from the hunters' guns. Wild yaks are probably the wildlife species under the greatest threat in Tibet today. Despite the fact that wild yaks are officially protected under Chinese wildlife protection legislation, poaching of wild yaks continues and wildlife authorities are often ill-equipped to deal with organized gangs of poachers. Preserving the remaining herds of wild yaks is crucial for biodiversity conservation. Without the wild yak, the rangelands of Tibet will have lost one of its characteristic species.

Box 5. The Tibetan Black-Necked Crane

One of the rarest and least known of the world's 15 crane species, the charismatic black-necked crane was the last species of cranes discovered and described by ornithologists due to the remoteness of their range. Endemic to the Tibetan plateau, the black-necked crane population is estimated at about 6,000. The species breeding range includes much of the Tibetan plateau. Six wintering populations are identified with half of these found in the lower elevations around Lhasa. About 70% of the black-necked crane population spends the winters in Tibet. Most black-necked cranes nest outside of protected areas. They are endangered throughout their range and are listed on Appendix I of CITES.

The black-necked crane is of cultural and mythological significance to Tibetans. Cranes are regarded as supernatural spirits throughout their range and appear often in religious images on temple walls. Cranes are also regarded as a symbol of luck and happiness. Local religious beliefs have played a critical role in safeguarding black-necked cranes. Cranes are tolerant of people and often establish territories near pastoral settlements.

Loss and degradation of habitat are the main threats faced by black-necked cranes. Threats are most serious in the wintering areas, where wetlands have been extensively affected by agricultural development. Changing agricultural policies that favor fall plowing of harvested barley and increased cultivation of winter wheat provide little grain residue for cranes. Priority conservation measures for black-necked cranes include efforts to control poaching, improving management of existing reserves, protecting wetland, and establishment of agricultural management zones in key wintering locations to limit the use of pesticides and to promote crops and methods of farming to provide suitable winter food for cranes. Wildlife conservation cannot be accomplished only within protected areas. The future of the black-necked cranes in Tibet and other wildlife will depend on preserving wildlife within the vast and productive agricultural areas.

Box 6. Tibetan Antelope Migration: An Exceptional Rangeland Ecological Phenomena

Large scale migrations of large terrestrial mammals are vanishing from the earth. Rangeland ecosystems that once supported extensive animal movements and seasonal concentrations of large grazing animals are increasingly threatened by expanding human populations, habitat destruction, and development activities. Ungulate migrations can have major influences on rangeland ecosystem dynamics and there has been considerable interest in describing and understanding the migratory movements of ungulate populations. Large migratory ungulate populations can influence nearly all other components of an ecosystem and, therefore, acts as a keystone species.

On the Tibetan plateau, the annual migration of the endangered Tibetan antelope (*Pantholops hodgsoni*) from their winter ranges to their traditional birthing grounds is an event that reveals one of the earth's outstanding ecological spectacles. Like the migration of caribou in North America and wildebeest in East Africa, this annual event has taken place for thousands of years unimpeded by people, roads, or fences. The northwestern Tibetan plateau, known as the *chang tang*, epitomizes one of the best remaining examples of native flora and fauna in central Asia. In fact, the relatively undisturbed wilderness and the herds of large wild herbivores and their predators in the area represent one of only a few such assemblages on earth, prompting the renowned field biologist George Schaller to refer to it as a "high-altitude Serengeti".

There is evidence for at least four and possibly more major migratory Tibetan antelope populations on the Tibetan plateau, each with different migration routes. Two behavior patterns are key to understanding the migration phenomenon of Tibetan antelope. First is that the sexes segregate almost completely in the summer. In late spring, male offspring of the previous year separate from their mothers and join adult males, which part from the females then. Adult females and their female offspring migrate north in May and June to specific calving grounds, in some cases traveling a distance of almost 500 km. Males, on the other hand, travel only a relatively short distance from their winter ranges. The second pattern is that antelope are divided into distinct populations, each with specific wintering and calving ranges. Understanding Tibetan antelope migratory movements could provide valuable insight into the structure and function of the Tibetan plateau ecosystem and assist in conservation efforts to protect biodiversity.

Once widespread and numerous, Tibetan antelope numbers have been greatly reduced in recent decades as a result of poaching and loss of habitat. Despite being fully protected by Chinese wildlife protection laws, Tibetan antelope have been indiscriminately slaughtered for their valuable cashmere, known as *shatoosh*, which is smuggled to India and made into valuable shawls. Increasing livestock numbers have also impacted Tibetan antelope and displaced them from much of their original habitat.

The Government of China has recognized the threats facing Tibetan antelope and other endangered species on the Tibetan plateau and in recent years has established three large nature reserves, Chang Tang, Kekeshili, and Arjin Shan to protect wildlife. In almost all of these reserves, however, the entire migratory range of the Tibetan antelope is not included within the boundaries of the protected areas. Reserve staff are also poorly trained and equipped.

The continuation of Tibetan antelope migration, one of the last great ecological marvels on earth, depends on better protection of the species, improved understanding of their ecology and the dynamics of the Tibetan plateau ecosystem, and innovative approaches to conservation and pastoral development that adopt participatory, integrated ecosystem management models.

International concern about greenhouse gases and their impact on climate change has added to increased interest in the role of rangeland ecosystems in the carbon cycle. Rangelands play a very important role in global climate change through the process of carbon sequestration. Grasslands occupy about half of the world's land area, and contain more than a third of above and below-ground carbon reserves. Many rangeland

management techniques intended to increase forage production may potentially increase soil organic matter, thus sequestering atmospheric carbon. The rangelands of the Tibetan plateau are a large repository of soil carbon because of their high carbon density and the vast area they occupy. Overgrazing, land degradation and desertification, however, reduces local, regional, and global carbon sequestration and potentials for carbon sinks. Improved rangeland management could increase soil carbon sequestration, while improving their production potential and other environmental benefits.

The Tibetan plateau contains one of the largest pastoral areas on earth. Although productivity of much of the rangeland is low, the grazing lands nevertheless sustain about 12 million yaks and 30 million sheep and goats and provide livelihood for about 4 million pastoralists and agropastoralists. Tibetan nomadic pastoralism evolved through long-term adaptation and persistence in a harsh environment and the grazing and livestock management systems that developed were intelligent, aggregate behavioral responses by Tibetan herders to the resources and risks of one of the most inhospitable rangeland environments on earth. Over centuries, Tibetan nomads acquired complex indigenous knowledge about the environment in which they lived and upon which their lives depended (Box 7). This knowledge enabled them to develop sophisticated range-livestock management practices in an environment that posed considerable risks.

The survival yet today of numerous, prosperous groups of Tibetan pastoralists bears witness to the wide-ranging indigenous knowledge, resourcefulness, and animal husbandry skills of Tibetan nomads. Despite increasing rangeland degradation, the fact that much of the rangeland ecosystem on the Tibetan plateau is still intact and sustains a unique flora and fauna, despite centuries of livestock grazing, indicates the existence of a remarkably resilient rangeland ecosystem. It also bears witness to the extraordinary capacity of the Tibetan rangelands, as well as to the sustainability of their resources if used wisely.

2.5. Forests

Forests on the Tibetan plateau are mainly found in southeast Qinghai, northwest Yunnan, west Sichuan, and east Tibet, but some forests are also found along the northern slopes of the Himalaya in Tibet. Although comprising less than 10% of the land area of the plateau, forests are vital ecosystems and support rich biodiversity. Forest ecosystems are most diverse in southeast Tibet, where five to six vertical zones have been described. Below 1000 m in elevation is a tropical, evergreen dipterocarp forest that grades upward into a semi-evergreen broad-leaved forest of *Castanopsis*. Above it, to about 2500 m, evergreen broadleaved forests of primarily oak (*Quercus*) are found at the lower level and also pine (*Pinus*) higher up. Fir (*Abies*), hemlock (*Tsuga*), and spruce (*Picea*) mixed with broad-leaved species such as *Acer* and *Magnolia*, occur above 2500 m up to 4000 m. At the higher elevations, most broad-leaved species disappear, leaving an understory of *Rhododendron* and, at the timberline, of birch (*Betula*). Alpine shrublands dominated by *Rhododendron, Rosa, Salix,* and *Lonicera* mixed with meadows extends to 4800 m.

Box 7. Tibetan Nomads' Indigenous Knowledge

Over hundreds of years, Tibetan nomads acquired intricate ecological knowledge about the rangeland ecosystems in which they live and upon which their livestock production economies depend. Nomads' husbandry of land, water, plant, and livestock resources and their strategies are highly skilled, complex and organized, reflecting generations of acute observation, experimentation, and adaptation to a harsh environment. Local climatic patterns and key grazing areas were recognized, allowing herders to select favorable winter ranges that provided protection from storms and sufficient forage to bring animals through stressful times. Forage plants were identified that had special nutritive value. Other plant species were known for their medicinal properties or as plants to be avoided since they were poisonous. A wide diversity of livestock and grazing management techniques were employed which enabled nomads to maintain the natural balance of the land upon which they were dependent. For example, nomads usually raise a mix of livestock species; each species has its own specific characteristics and adaptations to the environment. This multi-species grazing system maximizes the use of rangeland vegetation. Maintaining mixed species herds is also a risk management strategy employed by nomads to minimize loss from disease or harsh winters.

The organization of traditional Tibetan nomadic pastoralism, which emphasized multi-species herds, complex herd structures, regular movements of livestock, and linkages with agricultural communities developed as a rational response to the risks of the rangeland ecosystem. Complex forms of social organization within nomadic societies also developed that aided allocation of rangeland resources and, through trade networks with other societies, secured goods not available within the pastoral systems. Tibetan pastoralism evolved through long-term adaptation and persistence in a harsh environment and the grazing and livestock management systems that developed were rational responses by herders to the resources and risks of an inhospitable environment. Nomads mitigated environmental risks through strategies that enhanced diversity, flexibility, linkages to support networks, and self-sufficiency. Diversity is crucial to pastoral survival. Nomads keep a diverse mix of livestock in terms of species and class; they use a diverse mosaic of grazing sites, exploiting seasonal and annual variability in forage resources; and they maintain a diverse mix of goals for livestock production. The organizational flexibility of traditional nomadic pastoralism, which emphasized mobility of the multi-species herds, was a fundamental reason for nomads' success on the Tibetan plateau.

The expanded appreciation for the complexity and ecological and economic efficacy of traditional Tibetan pastoral systems is encouraging. It provides hope that the vast indigenous knowledge nomads' posses will be better understood and used in designing new interventions. Greater awareness of the need to understand existing pastoral systems should also help ensure that the goals and needs of Tibetan nomads are incorporated into new development programs and that nomads become active participants in the development process. Pastoral development programs must involve nomads themselves in the initial design of interventions. Nomads' needs and desires must be heard and the vast body of indigenous knowledge they possess about rangeland resources must be put to use when designing new range-livestock development projects. An important message for pastoral policy-makers and planners is the need for active participation by the nomads in all aspects of the development process and for empowered nomads to manage their own development.

In eastern Tibet and western Sichuan, forests are found up to elevations of 4100-4500 m. These are mixed coniferous and broad-leaved forests of mainly spruce, fir, and oak. In eastern Qinghai forested area is small and scattered, consisting mainly of spruce and junipers (*Sabina*), which are found up to 4400 m in some locations. Important mammals found in the forests of the Tibetan plateau include the giant panda, takin, red goral, forest musk deer, white-lipped deer, and snow leopard. The region also has the world's richest variety of pheasants and their relatives.

The diversity of the forested region in the southeastern Tibetan plateau is particularly impressive, with about 12,000 plant species, which is a little less than half of the total for all of China. Of these, about 3,500 species (29%) and at least 29 genera are endemic species, including about 100 endemic ferns. More than a quarter of the world's *Rhododendron* species in the Hengduan Mountains of western Sichuan, some 230 species, many of which are endemic. The forested region of the southeastern Tibetan plateau has been identified as a "hotspot" for conservation of the world's biodiversity (Boufford and van Dijk 1999).

The floods of 1998 on the lower Yangtze River, which caused a national disaster, directed Beijing's attention to the problems of deforestation and land degradation on the Tibetan plateau. In the wake of the floods, the government imposed a ban on logging and greatly expanded reforestation efforts. In 2000, China also established a program to convert marginal crop land on steep slopes on the Tibetan plateau to forests and pastures as a way to control land degradation and erosion.

The logging ban has halted much of the indiscriminate logging that was taking place on the Tibetan plateau, however there is still little sustainable forest management being practiced. Forest "protection" is now a major theme but most of this consists of propaganda to limit the possibility of forest fire and measures to check for illegal cutting. However, unmanaged livestock grazing in forested areas is still a major threat to biodiversity.

2.6. Agricultural land

Although agricultural land comprises less than 1% of the Tibetan plateau, agriculture is important to the economy. In the Tibetan Autonomous Region, crop production contributes about 35% of total agricultural output.[2] The Tibetan plateau has some of the highest elevation cropland in the world, with cropping in some parts of western Tibet taking place at 4900 m. The high elevation and extreme climatic conditions, which gives rise to a short growing season, has constrained the development of crop agriculture on much of the Tibetan plateau. The main cropping areas are in central and southern Tibet, along the Yarlung Tsangpo River, and along the main river valleys in western Sichuan and eastern Qinghai. Some of the most fertile cropland is found in western Sichuan.

Crops are sown on irrigated and non-irrigated land on valley floors. Barley and wheat are the main crops. Other crops include rapeseed, potatoes, peas, radish and fruits such as apples and peaches. Long sunshine time and intense solar radiation help to promote crop production. The yield of for wheat and barley is quite high and the weight of wheat per grain is higher than in other winter wheat growing areas of China.

Crop germplasm from the Tibetan plateau is an important aspect of biodiversity. For example, two species of barley are found in Tibet, *Hordeum vulgare and Hordeum brevisubulatum*, and *H. vulgare* has 5 subspecies and 288 varieties. This immense

[2] Animal husbandry contributes 52%, forestry 2% and subsidiary products contribute 11% to total agricultural production.

diversity in barley is an important germplasm for breeding varieties that are better adapted to local conditions. Fruit tree crops on the Tibetan plateau are also of significant value and Tibet is believed to be the place of origin for many fruit trees. There are also numerous species of wild berries and edible vegetables.

Beginning in the Great Leap Forward campaign (1958-1960), large areas of rangeland on the Tibetan plateau were converted to cropland as part of efforts to expand agricultural production. After a few years of poor harvests, many of the more marginal arable lands were abandoned and reverted back to pasture. Current agricultural policies in the Tibetan Autonomous Region require farmers to apply high rates of chemical fertilizers, in efforts to boost yields of wheat, often with negative environmental consequences.

Improving crop productivity on the Tibetan plateau is constrained by poor irrigation infrastructure, inefficient field water management, lack of proper seeds, poor crop management and inappropriate fertilizer application techniques, inadequate agricultural extension services, and poor market access.

2.7. Water resources

With the Tibetan plateau the headwaters for ten of Asia's major river systems, water resources are of critical environmental importance. The rivers flowing down from the Tibetan plateau feed the most populous regions on earth: China, India, Nepal, Bhutan, Bangladesh, Pakistan, Vietnam, Myanmar, Cambodia, Laos, and Thailand all depend upon Tibetan watersheds and rivers for their survival. Thus, water from the Tibetan plateau affects an estimated three billion people, 85% of Asia's population, and about half of the world's population. In addition to the numerous river systems, there are also over 2,000 lakes on the Tibetan plateau, with a combined area of about 35,000 sq. km. Two freshwater ecosystems found on the Tibetan plateau, the upper Yangtze River and the Upper Mekong and Salween Rivers are included in WWF's Global 200 list of priority ecosystems for conservation of the world's biological diversity; further evidence of the global significance of the Tibet's river systems.

The steep topography and abundant river flows results in considerable hydropower potential. A substantial proportion of river flows on the Tibetan plateau are stable or base flows coming from ground water and glacial sources. This is in marked contrast to river flows in the neighboring areas and countries, which are largely determined by seasonal rainfall patterns. The Tibetan Autonomous Region alone is estimated to have a hydropower potential of 200,000 megawatts, higher than any other country in the world. The largest hydropower potential in the world has been identified by Chinese scientists at the Great Bend of the Yarlung Tsangpo River in Tibet which could supply 70,000 megawatts of power (China's Three Gorges Dam will have a 18,200 megawatt capacity). In the Tibetan Autonomous Region, construction has just begun on the Zhigung hydroelectric plant on the Lhasa river in Mendrogongkar county, which will generate 400 million kWh annually. This will be Tibet's largest hydropower station. Recently, there has been environmental concern over a proposed hydroelectric project near Mugecuo Lake in Western Sichuan Province, because of the unique biodiversity of the region.

Rapid economic growth throughout the Tibetan plateau and adjoining regions of China has been accompanied by a substantial increase in demand for water and significant changes in the relative importance of different sources of water pollution. There is also increasing evidence that glaciers on the Tibetan plateau are receding. The rapid melting of glaciers is likely to result in an increase in glacial meltwater in the short-term, but a depletion of water resources in the long-term. Diminished water flows could cause catastrophic water shortages throughout the region.

2.8. Protected areas and biodiversity conservation

Significant progress has been made in the last 25 years to establish protected areas on the Tibetan plateau. One of the first reserves established was the Wolong Panda Reserve on the eastern edge of the plateau in Sichuan Province. In 1979, this area was added to UNESCO's World Network of Biosphere Reserves. The World Network of Biosphere Reserves is the main operational tool of the Man and the Biosphere (MAB) Program where an interdisciplinary approach to conservation and development is implemented. In 1997, the Jiuzhaigou Valley in northern Sichuan was added to the Biosphere Reserve network and in 2001, three more areas on the Tibetan plateau were included: Gaoligong Mountain in Yunnan Province, Huanglong in Sichuan Province, and Baishujiang in Gansu Province. With the addition of the Yading Reserve in southwest Sichuan in 2003, there are now a total of six Biosphere Reserves on the Tibetan plateau. Biosphere Reserves are unique areas that are noted not only for their high biological diversity, but also for their associated cultural values.

In recent years, there has been increasing interest to classify large areas of wilderness on the Tibetan plateau as protected areas, both because of the conservation and watershed benefits and the potential income that could be realized from ecotourism. Some of the larger and more important reserves that have been recently established on the Tibetan plateau include: the Qomolangma (Mt. Everest) Nature Reserve in Tibet (33,000 sq. km); the Arjin Shan Reserve in Xinjiang (45,000 sq. km); the Chang Tang Wildlife Reserve in Tibet (334,000 sq. km); the Kekeshili Reserve in Qinghai (45,000 sq. km); the Xianza Reserve (40,000 sq. km) in Tibet, the Mid-Kunlun Reserve in Xinjiang (32,000 sq. km) and the Yarlung Tsangpo Canyon Reserve in Tibet (9,600 sq. km). In Tibet alone, there are now a total of 18 reserves, which covers about one-third of the land area of the Region, or about 400,000 sq. km.

Both Jiuzhaigou and Huanglong in western Sichuan Province are also World Heritage Sites. The World Heritage Committee recently recommended that a number of areas on the Tibetan plateau be nominated as World Heritage sites. These include: Mt. Kailas in western Tibet, Three Parallel Rivers National Park in western Sichuan, Arjin Shan Nature Reserve in southern Xinjiang, and the areas in Tibet adjoining the Sagarmatha (Everest) National Park and Kanchanjunga National Park in Nepal.

Despite the number of reserves and land area enjoying protected area status, conservation in these protected areas still faces many problems. So far, only the Qomolangma (Everest) Nature Reserve has made significant progress towards developing a long-term management program. For most of the other reserves, only

preliminary surveys have been done and there is an urgent need for further research and comprehensive management plans. Since almost all the reserves on the Tibetan plateau have people living in them, management of reserves has to consider the needs of the local people. This presents a considerable challenge to both policy makers and reserve managers. Biodiversity conservation problems on the Tibetan plateau are mainly social and economic, not scientific (Schaller 1998:285). Creation of protected areas often creates hostility on the part of the nomads because of restrictions placed on traditional activities, both livestock grazing and subsistence hunting. Maintaining and managing reserves in the remote regions of the Tibetan plateau is difficult. For conservation to succeed it must involve the local people and incorporate their knowledge, skills and traditions.

2.9. Major threats and environmental issues

The Tibetan plateau is a region of physical extremes, characterized by high altitude, intense solar radiation, cold winter conditions, high winds, a short growing season, and predominantly steep terrain. These factors have presented a major challenge for human settlement and demanded special physical, physiological and cultural adaptation by the Tibetan population. This has resulted in a society with strong adherence to the land and to survival skills among the farmers and nomads that are intimately integrated with their daily activities. Now, however, there is a need for Tibetans residing on the Tibetan plateau and other concerned people to recognize the environmental and socio-economic changes that are taking place, the effects they are having, and to better define responses to these issues as part of a sustainable development process.

2.9.1. Rangeland degradation and sustainability of livestock production. The rangeland ecosystem of the Tibetan plateau is becoming a region of increased local and international environmental concern. The economic viability and environmental sustainability of the Tibetan rangelands are under considerable scrutiny. Across much of the region, human population pressure, environmental mismanagement, inappropriate policies, and the effects of global climate change have collided head-on, leading to widespread land degradation and increased poverty among the pastoral population.

Large expanses of the rangelands are degraded and desertification is spreading calling into question the long-term sustainability of the rangelands under current uses. In Qinghai Province, it is estimated that 90% of the rangelands are degraded to some degree, with 33% of the useable rangeland seriously degraded. Rangeland degradation is caused by many complex factors, but it is hard to avoid the conclusion that the most fundamental underlying cause has been poor government development policies relating to the pastoral areas (World Bank 2001). Current livestock production systems in many areas now appear to be unsustainable and the development of intensive livestock production systems as a means to increase production of livestock products and alleviate poverty in pastoral areas will place additional pressure on rangeland ecosystems.

Rangeland degradation not only results in a loss of the productive capacity to produce forage for wildlife and domestic animals, but also reduces other rangeland benefits, including (i) biodiversity values, which have declined in terms of the number, variety,

and range of wildlife on the rangelands of the Tibetan plateau; (ii) watershed protection; and (iii) air quality.

A critical crisis is emerging as China attempts to transform the traditional Tibetan nomadic pastoral system to one more oriented towards a market economy. The goal of livestock production in Tibetan nomadic pastoral areas, as in other pastoral regions of China, has been to increase livestock off-take. This has been promoted through privatization of herds and rangeland, settling of herders, introduction of less mobile, more static, organization of livestock production, intensive grazing management strategies, and introduction of rain-fed farming techniques for growing forage. Many of these interventions have been responses to political or economic objectives and while they have improved the delivery of social services, in many instances, they have conflicted with the goal of maintaining rangeland health and stability. Programs to settle pastoralists, to divide and allocate the rangeland to individual herders, and to fence the rangeland, fundamentally alter the mobile nature of traditional Tibetan nomadic pastoralism and jeopardize many worthy aspects of the indigenous pastoral systems. The migratory herd movements between seasonal rangelands, a fundamental characteristic of traditional nomadic pastoralism, are being reduced or eliminated with the move towards smaller, fenced pastures and the growing of fodder. The traditional composition of pastoralists' herds, perfected over many years to the intrinsic resources and risks of the Tibetan environment, are being restructured along Western-style, commercial livestock production guidelines. With present policies and livestock development approaches, nomadic pastoralists are compelled to become livestock farmers. These attempts to foster sedentary livestock production systems have a high probability of destroying the highly developed pastoral system that has existed for centuries on the Tibetan plateau. Both the rangeland environment and the indigenous nomadic pastoral cultures are under threat in areas where the culture of mobile pastoralism has been eliminated or substantially reduced. (Humphrey and Sneath 1996)

Much of the problem stems from the inability of traditional Chinese society, which is based on labor-intensive agriculture, to accommodate flexibility and mobility that makes nomadic pastoralism possible and sustainable (Box 8). In China, many attitudes towards rangelands and nomadic pastoralism appear to be influenced by the notion that sedentary agriculture, particularly crop-based agriculture, is the superior development option. Rangelands are viewed as systems to be controlled and modified, much like cropland, rather than to be managed as natural ecosystems. This view is reflected in many of the terms that are used in discussion of livestock development such as 'grassland construction' and 'grassland ecological-engineering'. Pastoral development is generally focused on agronomic and production aspects instead of rangeland ecological sustainability. There is a similarly narrow-minded view of traditional Tibetan nomadic pastoralism. Views are widespread that nomadic pastoral systems are 'backward' and are believed to lead to unsustainable increases in livestock numbers and to rangeland degradation. The purposeful movement of nomads' herds is often viewed as wandering and unsound type of use of the rangeland, instead of efficient means for utilizing forage in a harsh environment. Traditional herd structures, perfected over centuries are seen as 'irrational' and 'uneconomic' and herders themselves are often perceived as 'ignorant'.

Despite its extent and importance, the Tibetan plateau has received little attention from ecologists and nomadic pastoral specialists. This lack of information limits the proper management and sustainable development of the rangelands. Rangeland ecosystem dynamics are still poorly understood and good, scientific data on ecological processes taking place throughout the plateau are limited. Many questions concerning how rangeland vegetation functions and the effect of grazing animals on the pastoral system remain unanswered for the most part. There is a need for more in-depth analysis of the relationship between herbivores and the vegetation resource and the relationship between domestic livestock and wild herbivores in the pastoral areas.

Box 8. Nomads "In the Way" of Modernization

Chinese rangeland policy initiatives are informed by a long history of antagonism with the grassland environment and its native inhabitants. For centuries, Chinese literati viewed and described neighboring mobile populations and their homelands in the most disparaging terms. These derogatory Confucian attitudes were only strengthened by Marxist orthodoxy after 1949. The Marx-Lenin-Mao line of political philosophy viewed nomadic pastoralism as an evolutionary dead-end standing in opposition to national progress, scientific rationalism, and economic development. Mainstream Chinese intellectuals in the reform era still consider the land and people to be "in the way" of modernization – obsolete and disposable in their traditional composition.

Source: Williams (2002:10)

The socioeconomic dimensions of Tibetan nomadic pastoral production systems are also not well known. Greater efforts need to be directed towards developing a better understanding of current livestock production practices and how they are changing and adapting to development influences. Practices vary considerably across the plateau and these differences need to be analyzed. Why do nomads in different areas maintain different livestock herd compositions? What are current livestock offtake rates and how do increasing demands for livestock products in the marketplace affect future livestock sales? What constraints and opportunities for improving livestock productivity are recognized by the nomads themselves? What forms of social organization exist for managing livestock and rangelands? How have these practices changed in recent years and what are the implications of these transformations? Answers to these, and related questions, will help to unravel many of the complexities of the Tibetan plateau rangeland ecosystem, of which we still know so little about.

Although there is much in common across the Tibetan pastoral areas there are also striking regional differences that need to be addressed at local community levels. This calls for strengthened community participation and the development of sustainable participatory mechanisms for community-based rangeland resource management. Improved analyses of the socioeconomic processes at work in Tibetan pastoral areas are urgently required. Promoting rangeland sustainability and poverty reduction is also going to require increased attention to Tibetan women and their role in range management and conservation (Box 9). It will also be important to determine which aspects of indigenous knowledge systems and traditional pastoral production strategies can be built upon and

used in the design of new rural development interventions for tackling poverty and conserving the natural resources.

Tibetan nomads have played an important role in the rangelands for thousands of years. As such, the social dimension of rangeland ecosystems should be an important aspect of research and development on the Tibetan plateau but, unfortunately, it is not. In China, both organizational divisions between academic disciplines and the intellectual assumption that views human beings as separate from their natural environment have impeded the integration of social and natural scientific research. Chinese rangeland research primarily focuses on biotic interactions among soils, plants, and herbivores, with little attention paid to the behaviors and motives of the pastoralists. When Chinese researchers do focus on nomads, the information is typically limited to narrow economic parameters, reporting such figures as animal units, stocking ratios, and production/consumption levels (Williams 2002).

Box 9. Tibetan Nomad Women and Their Role in Conservation and Development

Throughout the rangelands of the Tibetan plateau, women play a very important role. Since they bear and rear children, women directly influence future human resources. As managers of the household and tent, women make vital decisions about the use of natural resources (e.g., fuel, water, grazingland). As herders, women are responsible for many of the activities regarding livestock production. Their decisions and actions have effects on rangeland resources and livestock. Efforts to improve livestock productivity, conserve and manage rangeland resources, reduce population growth, and improve nomads' livelihoods will, therefore, have to focus on Tibetan nomad women. These efforts will have to try and reduce women's time constraints; remove barriers to women's access to credit and extension advice; introduce technologies useable by and beneficial to women; and improve women's educational levels. Women are key actors in the sustainable development of the Tibetan plateau. The government, donors, researchers, and conservation and development specialists need to better acknowledge Tibetan nomad women's critical roles.

The issue is compounded by the rather narrow approach taken to rangeland ecosystem research. There has been a general lack of applied, interdisciplinary ecosystem-level research, which would provide a better basis for developing more integrated and sustainable rangeland and pastoral development programs for the Tibetan plateau. Researchers have generally neglected such topics as the effects of traditional pastoral systems on rangeland ecology, the dynamics of herd growth and traditional risk management strategies among nomads, and the impact of large numbers of Han Chinese farmers into Tibetan pastoral areas of Qinghai and Gansu Provinces to convert rangeland to cropland. A disproportionate amount of rangeland research is oriented to livestock and ways to maximize productivity from intensive livestock production, rather than understanding how livestock fit into the rangeland ecosystem and how to optimize production in an environmentally and socially sustainable way. The government is also facing a dilemma regarding the effective privatization of land tenure on the Tibetan plateau. There are high transaction costs associated with the policy, including high

private costs relative to the benefits and high public costs associated with monitoring and enforcing contractual provisions related to rangeland management.

China is facing major difficulties dealing with the simultaneous problems of improving the livelihoods of the Tibetan pastoral population while protecting and maintaining the numerous economic and environmental benefits provided by Tibetan plateau rangeland ecosystems. Current information on rangeland degradation suggests that current policies and development strategies are not working. Indeed, rangeland degradation in China is widely perceived as a technical problem for which there are technological solutions (Longworth and Williamson 1993). There are also policy contradictions that need to be resolved. Until recently, while the government was applying rangeland management and protection strategies to try to halt land degradation, it was also implementing policies that promoted conversion of rangeland to crop production. The problem of contradictory policies may worsen in the future if the government attempts to overdevelop its livestock sector or extract more resources from pastoral areas without considering the environmental and social consequences (World Bank 2001).

A serious re-evaluation of the approach being taken to rangeland management and pastoral development is needed. While there is no doubt that efforts to prevent particular types of land degradation are having positive effects in some areas, and there are some promising new productivity enhancing technologies for some locations, there has been insufficient adaptation of strategies and policies to suit local environmental or social conditions on the Tibetan plateau. All across China, the tendency has been to apply a "one-size-fits-all" approach, which is not acceptable given the diversity of rangeland ecosystems, the different pastoral production practices, and the cultural diversity of the people who rely on the rangelands (World Bank 2001).

Livestock production on the Tibetan plateau can be sustainable because rangeland ecosystems can tolerate the disturbance caused by livestock grazing. Much of the rangeland of the plateau is surprisingly resilient to livestock grazing; overgrazed rangeland can recover from livestock grazing naturally as long as the disturbance is not too great. Ecological processes that sustain rangeland for livestock also support wildlife, biodiversity and other natural resource functions.

2.9.2 Loss of biodiversity. The main driving forces behind biodiversity loss on the Tibetan plateau arise from human activities, and can be distinguished in terms of proximate and underlying causes.[3] Biodiversity loss has arisen from a combination of historic and modern factors. There has been a long and gradual historical process of conversion of natural ecosystems for agricultural and other purposes. Beginning in the

[3] Proximate causes refer to the direct over-exploitation of species (for example, through hunting, fishing, collection of medicinal plants) and the indirect impact of ecosystem degradation or destruction that leads to species (for example, through habitat alteration and conversion of rangeland to cropland). Underlying causes refer to the economic, social and cultural factors that lie behind the economic activities that lead to the direct depletion of species, and the destruction and degradation of their habitat. These underlying causes include the scale and growth of human population, culture and ethics, economic incentives, and institutions.

early 1950s, and particularly since the 1970s, the process was accelerated and was augmented by other major developments that have been detrimental to biodiversity conservation, including the creation of a large-scale forest industry on the eastern Tibetan plateau, expansion of crop agriculture, rodent control programs, and livestock development with the settling of nomads and fencing of the rangeland. For wildlife on the Tibetan plateau, the fundamental problem that makes their future so uncertain is that human use patterns that have held sway for centuries – and that provided for generally stable wildlife populations and healthy, if not entirely pristine habitats – have now changed. In the past, human pressures on wildlife and habitat were relatively low, but the situation is remarkably different now.

The major threats to biodiversity on the Tibetan plateau include: logging, livestock grazing and fencing of the rangeland, poisoning of rodents, poaching of wildlife, fuel collection and medicinal plant collection, desertification, and human population pressure. While logging is no longer a serious threat because of the implementation of the logging ban in 1999, livestock grazing, fencing of the range, and collection of fuelwood and medicinal plants are still threats to biodiversity. Unsustainable livestock production practices, which results in overgrazing and leads to habitat degradation and displacement of wildlife is undoubtedly one of the greatest threats to biodiversity throughout the Tibetan plateau (Box 10). Current policy and economic systems to prevent overgrazing and attendant rangeland degradation depend on a strong negative feedback loop between range conditions and producer profit. At this time, this feedback loop appears to be a loose one. Thus, overgrazing can be optimal from an economic and/or government policy perspective over the short-to medium term with negative effects on biodiversity (Harris 2002).

Biological complexity in rangeland ecosystems arises from spatially-linked ecological states and processes. Spatial heterogeneity plays a central role in the structure and function of grazed ecosystems, but current land use practices on the Tibetan plateau, and especially the privatization and fencing of rangeland, tends to compress the scale at which people and animals can respond heterogeneity by fragmenting large intact landscapes. As fragmentation occurs, rangeland ecosystems are simplified by breaking up interdependent spatial units into separate entities, compartmentalizing them into isolated sub-units. The result of this simplification is a reduction in the scale over which complex interactions among environment, large herbivores, and human management takes place (Hobbs and Galvin 2003). Fences may also entangle wildlife, transect or truncate migratory routes, excise important resources needed by wildlife, and allow resident herbivores to overpopulate, altering vegetation biomass or species composition. By eliminating access to heterogeneous forage patches within a landscape, fences can reduce options available to both wild and domestic herbivores.

Due to the shortage of natural forest cover, the Tibetan plateau is poor in fuel resources and many rural Tibetans are dependent on fuelwood from shrubs. Growing human demand has resulted in rapid overharvesting of sparse shrub cover in Southern Tibet, leading to increased desertification and biodiversity loss. Increasing aridity, diminishing vegetation cover and the spread of sand dunes are a major threat not only to biodiversity

but also to the livelihoods of millions of people. While the causes of biodiversity loss are many, there is little doubt that the government's natural resource management policies have been an important contributing factor.

Box 10. Impacts of Livestock Grazing on Biodiversity on the Tibetan Plateau

Livestock can have a wide range of effects on rangeland ecosystems of the Tibetan plateau. The impact of livestock grazing are varied and complicated. Livestock grazing can directly and indirectly impact plants, wildlife, and soils and have secondary or ecosystem-level effects that can be immediate or take decades to manifest. Some effects are long-lasting and others are only temporary. Some effects apply only in certain areas and not in others. Because several impacts often occur concurrently and that overall effects may be synergistic rather than additive, ecological impacts from livestock grazing are difficult to study or analyze with traditional reductionist methodologies. For example, livestock grazing may simultaneously reduce plant cover, alter plant species composition, increase erosion, and decrease infiltration. Livestock grazing can have secondary effects on wildlife by changing bird and small mammal composition through shrub and herbaceous cover reduction. The collective impact of all these processes may be far more severe than any impact in isolation.

It is necessary to keep in mind that livestock constitute only one component of rangeland ecosystems on the Tibetan plateau, and many extrinsic factors, especially weather variations are instrumental in altering ecosystem components. There is little argument that poor grazing practices were, and in many areas still are, a primary cause of redirecting or accelerating plant succession towards less desirable new plant communities. However, the practice of unwise livestock grazing has not been the sole factor contributing to changes in plant composition on Tibetan rangelands. Grazing along with both natural and anthropogenic factors has had a cumulative influence on plant succession and when interpreting vegetation trends on rangelands, it is often difficult or impossible to separate the effects of heavy livestock grazing from the myriad of interacting environmental parameters. Detecting biodiversity changes in rangelands is also complicated because of the rather subtle nature of many rangeland ecosystems. Among the more subtle impacts of livestock grazing are the effects of reduced habitat size, the lack of endemic species, and the highly developed ecotypic differentiation in rangeland environments, which is not detected in conventional measures of biodiversity.

The problem of biodiversity loss is not limited to just the direct costs of species extinction. In the rangeland ecosystems of the Tibetan plateau, it is the impact of a change in the mix of species that is important. For instance, a shift in vegetation composition from palatable plants to unpalatable plants and shrubs reduces the ecological support function of the rangeland ecosystem for grazing animals, both domestic and wild. A decrease in the capacity of rangelands for grazing animals has serious implications for current and future generations of people in the pastoral areas. Since so many pastoralists are dependent upon the grasslands for a livelihood, the socio-economic effects of grassland degradation are also serious.

2.10. Sustainability of biodiversity conservation

A recent GEF review[4] of sustainability of biodiversity conservation concluded that: (i) it is essential to identify clearly what biodiversity one seeks to sustain, on what scale, and

[4] Smith, S. and A. Martin. 2000. *Achieving Sustainability of Biodiversity Conservation: Report of a GEF Thematic Review.* Monitoring and Evaluation Working Paper 1. GEF, Washington, DC.

over what time period; (ii) since much biodiversity will remain outside protected areas; a discussion of sustainability must include conservation and sustainable use on privately owned lands; (iii) the major factors that affect sustainability are the socioeconomic and political[5] root causes of biodiversity loss; and therefore (iv) a comprehensive, long-term, and adaptive approach is needed to conserve biodiversity sustainably.

To conserve biodiversity on the Tibetan plateau, it will be necessary to move away from small, discrete projects in protected areas and embrace a larger, ecosystem level approach which sustains the ecological benefits contributed by the various ecosystem processes. Much of the biodiversity of the globally significant areas on the Tibetan plateau is found in the production landscape outside of the protected area network. It is in this largely rangeland production landscape where biodiversity conservation efforts will need to focus their attention.

Numerous areas on the Tibetan plateau are recognized as being globally important for biological diversity. They are also important locally and nationally and, in the case of the Himalayan sites, of regional importance to neighboring countries. It is recognized that it will not be possible to preserve all current biological diversity in these areas from the pressures of human population growth and the consequent increased consumption. Choices and trade-offs still have to be made, but there is already evidence for the political will at the central level that the natural resources of the Tibetan plateau need to be sustained. There is also indication at the central level of the need to conserve resources and ecological services of current or likely future use to people, as well as emphasis on the existence value of a wide diversity of ecosystems and species in their own right.

Conservationists and development specialists will need to clearly articulate the global environmental objectives of their efforts and the context in which conservation will occur to all the stakeholders. Efforts to conserve and sustainably use biodiversity will also have to be based on clear understanding of the choices and trade-offs and actions will have to be prioritized to optimize the chances of achieving conservation objectives. For this, all the stakeholders, especially those expected to bear the costs of biodiversity conservation, will have to participate in making the decisions. This requires adoption of a participatory planning approach with an emphasis on Tibetan nomads and farmers.

Land tenure patterns related to rangelands on the Tibetan plateau undoubtedly have a major influence on how nomads make decisions regarding resource use and are central to long-term sustainability of biodiversity. A recent research project on the environment and pastoral economy in Inner Asia[6] concluded that most of the rangeland degradation (and associated biodiversity loss) was associated with the loss of mobility of the pastoral systems. On the Tibetan plateau, one of the effects of privatizing livestock and rangeland has been to reduce the amount of movement undertaken by nomads. The research findings challenge the idea that sustainable pastoralism in Inner Asian steppe regions can

[5] By "political" means the policies that provide the incentives and disincentives related to conservation and sustainable use of biodiversity, the processes by which these policies are made and enforced, and the influences of groups or individuals on these processes.

[6] Environmental and Cultural Conservation in Inner Asia, mainly funded by the MacArthur Foundation.

be achieved without retaining mobility. More recent initiatives to fence rangelands also pose a threat to biodiversity. Development specialists interested in the sustainability of Tibetan rangeland ecosystems need to analyze the incentives and disincentives that influence how nomads make management decisions regarding rangeland use, and try to pilot new, participatory approaches that seek to maintain mobility of livestock in order to conserve biodiversity in the production landscape.

Land degradation and habitat loss are the major causes of biodiversity loss on the Tibetan plateau. However, it is recognized that the root causes of biodiversity loss – and thus the threats to sustaining that biodiversity – are found in the socioeconomic and political context that motivates local actions. A recent World Bank publication, *China-Air, Land and Water: Environmental Priorities for a New Millennium*, stated, "Grassland degradation is caused by many complex factors, but it is hard to avoid the conclusion that the most fundamental underlying cause has been poor government development policies relating to grassland areas." Fortunately, there is increasing awareness in China of the negative impact on the environment of many of the poorly designed policies in the past and growing constituencies for conservation within the government and society. Development and conservation groups working on the Tibetan plateau will need to actively address these root causes of biodiversity loss through field-based projects, the strengthening of conservation institutions and working with stakeholders to adjust policies and incentives.

Finally, it is necessary to take a comprehensive, strategic approach to conserving and sustainably using biological diversity by adopting an integrated ecosystem approach to the management of rangelands. Contemporary approaches have largely been ineffective in tackling land degradation and biodiversity loss problems because the linkages and interactions among the natural systems as well as with the various stakeholders have not been taken into account. Innovative interventions are required that embrace more holistic and integrated approaches to the management of natural resources and the process of rural development. It will also be necessary to mainstream biodiversity and wide-ranging ecosystems concerns into natural resource management in the broader, production rangeland landscape. Conserving biodiversity on the Tibetan plateau can no longer be restricted to single habitat types or protected areas but must move out to encompass entire ecosystems. Reversing environmental degradation is also fundamental to poverty reduction on the Tibetan plateau, since the poor nomads and farmers are the most dependent on natural resources for their livelihoods. They are also the most vulnerable to environmental disasters and whose health is most affected by environmental pollution.

In view of the linkages between local rural development and sustainable use of rangeland resources, priority should be given to promoting projects that adopt village-based rangeland resource management planning.[7] This innovative way to go about pastoral development applies integrated ecosystem management approaches on a landscape scale

[7] Village-based rangeland resource planning utilizes remote sensing, GIS, and ground-based vegetation monitoring, along with socio-economic data to plan grazing management and livestock development. It is now being institutionalized in a new World Bank project, the Gansu-Xining Pastoral Development Project, in pastoral areas of Gansu Province on the Tibetan plateau and in Xinjiang Autonomous Region.

to optimize the positive ecological, social, and economic benefits of interventions aimed at maintaining and restoring rangeland ecosystem structure and function. Pastoral development specialists and conservationists will also need to coordinate actions into phased and flexible programs, scaled to local institutional capacity, and with discipline provided by results-oriented milestones and effective monitoring and evaluation systems to make biodiversity conservation on the Tibetan plateau sustainable.

2.11. Policy framework

The Government of China has developed a strong legal framework for environmental protection and biodiversity conservation. There are numerous laws directly relating to environmental management and biodiversity conservation. These include laws on environmental impact assessment, laws on forests, natural plants, hunting, protected areas, and laws on the use of water, forest, rangelands, minerals, and wildlife. China is a signatory to many major environmental-related international conventions. Some of the most important include the Convention on Biodiversity, Convention on Climate Change, Convention on Trade in Endangered Species (CITES), the Convention on Combating Desertification, and the International Convention on Wetlands.

Together with donors and NGOs, the Government of China has developed and implemented a large number of strategies and programs dealing with environmental and biodiversity issues, including the Biodiversity Conservation Action Plan (1994), National Environmental Action Plan (1998), and the National Action Program to Combat Desertification (2001).

3. ACTIONS NECESSARY TO SUSTAIN THE ENVRIONMENT

To sustain the environment on the Tibetan plateau, China needs to re-orient its policy objectives, not only in terms of range management and livestock production, but also in the management of rural development itself. The traditional approach of maximizing agricultural output is no longer relevant to current circumstances. The need now is for ecologically and economically sustainable development of the Tibetan plateau, neither of which is consistent with output maximization. Policies and development strategies for the Tibetan plateau need to consider the ecological constraints inherent in the environment, the interests and aspirations of the local population, and alternative methods of meeting social objectives for the herding and farming communities. Sustainable development of the Tibetan plateau also needs to recognize the significance of Tibetan nomads' and farmers' indigenous knowledge of the environment and management of natural resources. Rural development can no longer ignore local circumstances, local technologies, and local knowledge systems. Traditional pastoral production practices have been tried and tested. In many cases, they are still very effective and are based on preserving and building on the patterns and processes of the rangeland ecosystem.

The challenge for the 21st Century is to balance the diverse economic, cultural and social needs of Tibetan plateau inhabitants and users with the need to maintain its rangeland resources and conserve the biodiversity and cultural heritage of these landscapes. There are no simple solutions to addressing development and environmental issues on the

Tibetan plateau. Due to the multifaceted dimensions of the problems, actions will need to be taken on several levels: at the central policy level; at the university and research center level; at the level of animal husbandry and agricultural extension services; and at the herder and farmer level. Promoting more sustainable development on the Tibetan plateau will also require policies and approaches that integrate ecological principles regulating rangeland ecosystem functions with the economic principles governing livestock production and general economic development processes.

The challenges facing pastoral production, environmental conservation and sustainable development on the Tibetan plateau are considerable. Opportunities do exist, however, for improving the management of rangeland resources, conserving biodiversity, increasing livestock productivity, and bettering the livelihoods of the nomad population. Programs stressing multiple use, participatory development, sustainability, economics, and biodiversity conservation could be realized through complementary activities in natural resource management, livestock and agricultural production, and environmental conservation. Implementing such programs requires a better understanding of the ecosystems, greater appreciation for Tibetan nomads and farmers and their ways of life, and consideration of new information and ideas emerging about rangeland ecology, nomadic pastoral systems, and approaches to rural development.

3.1. Adopting an integrated ecosystem approach

Land degradation and loss of biological diversity are enormous problems and at the root of the poverty being faced by poor herders and farmers on the Tibetan plateau. Given the extent and severity of the degradation, it is unlikely that demand-driven investment projects alone will be able to effectively address the problems without considerable technical assistance, capacity building, research, and targeted investments to pilot new development paths that integrate economic growth, the environment, and social equity. In addition, traditional and current attempts to address land degradation, biodiversity loss, and the management challenges they pose are based on narrow, sector-by-sector approaches, which results in fragmentation of policies and interventions. These contemporary approaches have largely been ineffective in tackling the land degradation problem because the linkages and interactions among the natural systems as well as with the various stakeholders have not been taken into account.

Thus, there is an urgent need to initiate new interventions that embrace more holistic and integrated approaches to the management of natural resources and the process of rural development. Conservation and sustainable use of biodiversity on the Tibetan plateau, where there are a number of ecosystems recognized as global priority areas, also requires mainstreaming biodiversity and wide-ranging ecosystem concerns into natural resource management in the broader production grazingland landscape. Conserving biodiversity can no longer be restricted to single habitat types or protected areas but must move out to encompass entire ecosystems. Reversing environmental degradation is also fundamental to poverty reduction, since the poor Tibetan herders and farmers are the most dependent on natural resources for their livelihoods. They are also the most vulnerable to environmental disasters and whose health is most affected by environmental pollution.

To cope with the environmental degradation taking place nowadays and the inevitable increases in consumption that will come in the future, an integrated ecosystem approach needs to be adopted. Biodiversity conservation, ecological sustainability, and economic sustainability are inexorably linked and sustaining ecosystem function and retaining ecosystem resilience requires new methods to maintain the productive potential of the Tibetan plateau environment. The principles of an ecosystem approach, described in are gaining recognition among natural managers worldwide and the concept has been growing in both theory and application (Box 11). For the Tibetan plateau, Table 4 provides examples of the differences between current approaches to range and livestock development and an integrated ecosystem approach to development of the pastoral areas.

Box 11. What is an Ecosystem Approach?

- *An ecosystem approach is an integrated approach.* Currently, we tend to manage ecosystems for one dominant good or service, such as timber or forage for livestock without fully realizing the tradeoffs we are making. In doing so, we may be sacrificing goods or services more valuable than those we receive – often those goods and services that are not yet valued in the marketplace such and biodiversity and flood control. An ecosystem approach considers the entire range of possible goods and services and attempts to optimize the mix of benefits for a given ecosystem. Its purpose is to make tradeoffs efficient, transparent, and sustainable.
- *An ecosystem approach reorients the boundaries that traditionally have defined our management of ecosystems.* It emphasizes a systematic approach, recognizing that ecosystems function as whole entities and need to be managed as such, not in pieces. Thus it looks beyond traditional jurisdictional boundaries, since ecosystems often cross state and national lines.
- *An ecosystem approach takes the long view.* It respects ecosystem processes at the micro level, but sees them in the larger frame of landscapes and decades, working across a variety of scales and time dimensions.
- *An ecosystem approach includes people.* It integrates social and economic information with environmental information about the ecosystem. It thus explicitly links human needs to the biological capacity of ecosystems to fulfill those needs. Although it is attentive to ecosystem processes and biological thresholds, it acknowledges an appropriate place for human modification of ecosystems.
- *An ecosystem approach maintains the productive potential of ecosystems.* An ecosystem approach is not focused on production alone. It views production of goods and services as the natural product of a healthy ecosystem, not as an end it itself. Within this approach, management is not successful unless it preserves or increases the capacity of an ecosystem to produce the desired benefits in the future.

Source: World Resources Institute (2002)

World Resources Institute (2002), in its global analyses of ecosystems, made the following four recommendations for guiding adoption of an ecosystem approach:

- Tackle the science and information gap;
- Recognize and measure the value of ecosystem services;
- Engage in a public dialogue on goals, policies, and tradeoffs; and
- Involve all stakeholders in ecosystem management.

Table 4. Current Pastoral Development Policies on the Tibetan Plateau Contrasted with an Integrated Ecosystem Approach

Topic Area	Current Pastoral Development	Pastoral Development and an Integrated Ecosystem Approach
Objectives	• Maximizes livestock production	• Maintains rangeland ecosystems as an interconnected whole, while allowing for sustainable rangeland *and* livestock commodity production
	• Aims to increase livestock offtake	• Aims to sustain rangeland productivity over time while simultaneously considering tradeoffs with other rangeland goods and services
	• Maximizes net present value	• Maintains future options
Scale	• Works within political, administrative or ownership boundaries	• Works at the ecosystem and landscape level
Role of Science	• Views rangeland management as an applied science focused on grassland resources	• Views rangeland management holistically, combining science and social factors
Role of Management	• Focuses on outputs (goods and services demanded by people) such as forage, livestock products, and timber.	• Focuses on inputs and processes, such as soil, biodiversity, and ecological processes since these give rise to goods and services
	• Strives for management that fits industrialization of the animal husbandry sector	• Strives for management that mimics natural rangeland processes and productivity
	• Focuses on preventing land degradation	• Focuses on protecting and conserving rangeland ecosystem goods and services
	• Emphasizes intensification of agriculture through more efficient use of land, labor and capital	• Emphasizes maintaining or increasing the capacity of rangelands to provide goods and services
	• Strives to avoid food insecurity and famine	• Strives to preserve the entire array of rangeland ecosystem goods and services
	• Values economic efficiency	• Values cost-effectiveness and social acceptability

Source: Adapted from White, et al. 2002. *An Ecosystem Approach to Drylands*

Managing the Tibetan plateau environment holistically and sustainably requires a thorough understanding of the plateau's ecosystems function and condition. Without strong scientific knowledge and indicators, assessing ecosystems' productive capacity is difficult. Better scientific understanding of rangeland ecosystems' carrying capacity and thresholds for change will also benefit management efforts. In addition to a better scientific base understanding of Tibetan plateau ecology, improved indicators, consistent monitoring, and reporting on ecosystem condition and performance are also needed.

For the Tibetan plateau rangelands, an essential element of an ecosystem approach is recognizing and measuring the value of rangeland ecosystem services, so that the government and communities can factor these values into their production and consumption choices. A first step toward setting these values is calculating the cost of economic policies that subsidize the use of natural resources. For example, heavily subsidized water prices, especially for irrigated agriculture, has promoted the inefficient use of water. Various policies and public-investment strategies have distorted the price of ecosystem inputs and outputs to the detriment of the environment.

With an ecosystem approach, knowledge of ecosystem processes and conditions serves as a foundation for public dialogue on goals, policies and trade-offs. All those who have a stake in the health of an ecosystem need to be brought together and participate fully in the development process. When all interest groups are part of the solution, the results are usually more sustainable than those achieved without broad stakeholder participation. Local governance systems that encourage community decision making can also create incentives for conservation and improved natural resource management at the local level.

Some of the key challenges for tackling biodiversity loss and land degradation in the rangeland ecosystems of the Tibetan plateau are:

- The need to improve information on the extent and state of the rangelands, and how they are changing over time.
- The need for ecologists to refine models of rangeland ecology and to work with economists, planners, managers, and local herders to design appropriate management systems for livestock production in complex, dynamic and fragile ecosystems. Economists and development planners need to take into account the wide range of productive uses of herders' varied livestock species, and the production objectives of the herders, when determining appropriate management regimes.
- The need to examine appropriate responses to the changing rangeland tenure regimes. Improving the efficiency and sustainability of the prevailing system of land tenure, based on traditional groups, may be more effective in managing the complex web of needs that the existing system had evolved to cope with problems such as uncertainty and risk aversion, flexible livestock herds and grazing patterns, and multiple uses of livestock. There is also a need to appraise fully the effects of policy interventions on land use decisions.

To address biodiversity conservation issues as they relate to livestock grazing in rangelands, more information is needed on the following:

- How livestock grazing can be managed to have the fewest impacts on biodiversity and ecosystem integrity;
- What elements of biodiversity are most affected by livestock;
- Under what conditions (e.g., of rainfall or livestock stocking levels) grazing effects will be magnified or reduced;
- What management actions can ameliorate livestock grazing problems;
- Information on the growth requirements and life histories of principal forage plants and how these plants respond to environmental pressures;
- The interactive effects of range management practices on plant communities;
- What the grazing tolerance, water relations, morphology, seed germination, and other factors are of key forage plants;
- The critical thresholds for plant communities and understanding succession, stability and resilience; and
- Time frames for rangeland resilience to changes from grazing pressure, especially for high elevation, degraded *Kobresia* sedge meadow communities.

Tackling biodiversity loss has to be addressed on many levels, but all efforts will be wasted if there is inadequate *in situ* protection. Finally, interdisciplinary collaboration on research and management of rangelands will be necessary in order to extend beyond the current frontiers of ecology, economics and other disciplines to deal with the fundamentally important phenomenon of biodiversity loss. Traditional ecological knowledge, or indigenous knowledge, of rangeland environments held by the Tibetan nomads will provide many clues to incentives that influence local people's behavior and could assist in the design of new incentive systems in situations where traditional resource management systems break down or are superseded.

3.2. Generating income from natural resources in a way that provides an incentive to conserve them.

A key challenge on the Tibetan plateau is to build linkages between biodiversity and natural resources and economic values and income. Natural resource trade-offs are increasingly made that unduly damage natural resources for at least three reasons. First, the value of resources is not reflected in prices/fees for their use (and fines for their mis-use). Second, there is a lack of alternative, less-damaging activities that bring income to local people but do not overexploit the natural resources. Third, communities and local people have few economic incentives to conserve natural resources.

Many of the natural resources on the Tibetan plateau are undervalued economically. In the case of rangeland, grazingland is generally used for only limited fees, if any. Forests, medicinal plants, wildlife, and water are all used for a fraction of their market value. The Tibetan plateau's largely rural population, high rates of poverty, the need for income, and poor government policies exacerbate the unsustainable use of natural resources. When it comes down to individual economic decisions and actions to put food on the table or earn much needed cash income, biodiversity concerns do not figure prominently, especially when biodiversity generates little discernible economic return. For example, there are numerous reports of Tibetan nomads engaged in the poaching of the endangered Tibetan antelope in national protected areas.

A number of proposals are now under consideration to allow oil exploration, mining, hydropower construction and other infrastructure related projects in areas of high biodiversity value. In most cases, these conflicts arise because the exploitation activity is economically beneficial, at least in the short term, to local decision-makers. Given the limited ability to enforce existing wildlife protection and environmental laws, the commitment of local communities and governments to protect and sustainably use natural resources will be at least partly based on perception of their economic value.

3.3. Strengthening markets, value-added natural resource processing, and financial services that reduce pressure on rangelands and biodiversity.

The economy of the Tibetan plateau is largely dependent on the production of raw and minimally processed products for domestic use. An economic emphasis on primary products increases impacts on the environment because economic returns are based more on quantity of natural resources exploited than on quality or added value of the products produced. Primary product natural resource based economies not only have greater direct negative impacts on the environment; they also mean that a given amount of natural resource provides fewer jobs and less income to the population. On the Tibetan plateau, the majority of the population directly depends on the use of natural resources for subsistence and economic livelihood. The lack of agro-processing and alternative livelihood options means that individual households have an economic incentive, at least in the short term, to maximize exploitation of natural resources, especially if they are open-access or commonly held resources.

The problem of overgrazing and rangeland degradation is an example. In many areas on the Tibetan plateau there are more animals than the rangeland can support, poor access to markets and social services, growing conflict over grazing land, and high vulnerability to natural disasters such as severe winter snowstorms. The lack of markets for livestock products, of agro-processing that adds significant value, and of financial services are important contributors to the environmental and economic problems afflicting rural areas on the Tibetan plateau.

Development of integrated markets for livestock and agricultural products that increase the flow of livestock, livestock products, and agricultural products and price signals that reward higher quality is essential for adding economic value, reducing the negative environmental impacts of overgrazing and environmental degradation, and improving the livelihoods of herders and farmer. Development of demand-based agricultural processing enterprises that add significant value to agricultural and natural resource products means a greater emphasis on quality rather than quantity. It also underscores the importance of providing increased alternative opportunities for employment and income for Tibetan herders and farmers. In addition, improving access to credit services for herders and farmers to invest in new technologies is important to reducing environmental pressures.

3.4. Improving enforcement of environmental laws and regulations

Despite China's relatively strong legal and policy framework for environmental and biodiversity conservation, implementation and enforcement of regulations is still very

weak, especially in the remote reserves on the Tibetan plateau. Low budgets and staffing for environmental enforcement, the high cost of enforcement given the large area and high transportation costs, and accountability and public participation all hinder effective enforcement. In the protected areas, there is lack of staff and funds for effective management.

Although Tibetan have a strong tradition of respect for nature, public involvement in development decisions related to natural resources and biodiversity is relatively weak. Many natural resource management decisions are made with little of no public consultation. Corruption is a concern and there are numerous reports of illegal hunting, illegal logging and illegal collection of wild plants. Improved implementation and enforcement of environmental regulations required better awareness and incentives for officials as well as better access to information.

Local environmental organizations and international conservation NGOs are becoming more active on the Tibetan plateau and are increasingly galvanizing public awareness of biodiversity and environmental issues. Strengthening civil society organizations and NGOs involved in environmental conservation could help with improving enforcement of environmental regulations and implementing environmental policies.

4. ENVIRONMENTAL EFFORTS ON THE TIBETAN PLATEAU

4.1. National and donor and NGO efforts

On the Tibetan plateau, China's State Forest Administration (formerly the Ministry of Forests) has been the major government agency responsible for biodiversity conservation. In recent years, the State Environmental Protection Agency (SEPA) has started to play a stronger role in biodiversity conservation as well as its more traditional role in environmental monitoring and regulation. The Bureau of Animal Husbandry of the Ministry of Agriculture has major responsibility for management of rangeland resources.

A number of donor programs have focused on various aspects of environmental management on the Tibetan plateau. Major donors include UNDP, World Bank, the European Union, Canadian International Development Agency (CIDA), AusAID, NZAID, German government (GTZ), and the Dutch government. The International Center for Integrated Mountain Development (ICIMOD), based in Kathmandu, Nepal also supports numerous activities related to natural resource management and environmental conservation on the Tibetan plateau.

4.2. US Government efforts

U.S. Government efforts to support environmental conservation on the Tibetan plateau has largely been through Congressional earmarked funds. These funds, which have never amounted to more than $3 million annually, have gone to NGOs based in America that are working with Tibetan communities in China to "preserve cultural traditions and promote sustainable development and environmental conservation". Not all of the

funding, however, is directed towards the environment, however, as much of the work of the NGOs has focused on education and health.

The Office of International Programs of the U.S. Forest Service has supported some environmental-related work on the Tibetan plateau in Sichuan and Yunnan Provinces. Recently, the Agricultural Research Service of the U.S. Department of Agriculture established a Center of Excellence for Grassland Sustainability in Lanzhou, Gansu Province that will be able to support collaborative research between American and Chinese rangeland scientists on the Tibetan plateau.

4.3. NGO efforts

A growing number of national and international NGOs are becoming active in environmental and development programs on the Tibetan plateau. Some of the major American NGOs include, The Bridge Fund, The Mountain Institute, Trace Foundation, International Crane Foundation, Terma Foundation, Tibet Fund, Heifer International, Future Generations, The Nature Conservancy, Conservation International, WWF, and the Wildlife Conservation Society.

Lately, NGOs involved with Tibet have ridden on a crest of a public reaction against large, donor-funded, top-down development approaches. NGOs are widely perceived by the public and donor community alike as more effective than larger donors at reaching poor Tibetan farmers and herders. NGOs are considered sensitive to local people, relatively cheap and good at community development. Typically, NGOs working n Tibetan areas of China operate small-scale, community-based rural development projects (including health and education), conservation, and/or cultural preservation/restoration of temples and monasteries.

In spite of the wide-spread praise in development circles for the NGO approach to development, the actual record of NGO projects in Tibet is rarely critically examined. This almost across-the-board willingness to suspend critical judgment cannot help either the NGOs in re-defining their programs to improve their impact nor the intended beneficiaries of their projects to reap maximum benefit from them. The actual performance of NGOs working in Tibetan areas is difficult to assess – particularly as the monitoring and evaluation components of many NGO projects are often poorly developed, and because of the remoteness of many of the areas where NGOs are working.
Whether the NGO approach is appropriate in tackling the longer-term poverty, environmental and natural resource management problems on the Tibetan Plateau is, however, open to question; many such problems involve local and even regional and central government level political and economic factors outside the local community.

For NGOs to become more effective at promoting sustainable development and environmental conservation on the Tibetan Plateau the following points should be considered:

- NGOs need to more clearly define their objectives and role in sustainable development and poverty reduction. If they are to empower local Tibetan

communities then an understanding is needed of what these communities are, what the process of empowerment is, and exactly how the communities are to be empowered.

- NGOs with a successful track record that can demonstrate results and impacts need to open up a dialogue with government and larger bilateral and multilateral donors on the future development of Tibetan areas of China. If NGO project interventions and approaches are to be sustainable then they must become part of mainstream government programs. Without this they run the danger of only further marginalizing Tibetans.

- Sustainable development in Tibetan areas requires that NGOs redirect attention away from small-scale operational projects such as building schools and clinics towards a more explicit advocacy and experimental role in poverty reduction and economic growth. IF NGOs are to have a wider impact than simply on the local community then they need to more clearly define their roles as (i) a catalyst, experimenting with a particular approach which can then be adopted by larger donors or the government, and (ii) an advocate, speaking out for the special challenges facing development in Tibetan areas. If they are to take on these roles they need to improve their knowledge of Tibetan agricultural and pastoral systems, and build up their analytical capability and capacity.

- NGOs need to more closely monitor project objectives and achievements. If NGOs are to pioneer new approaches to development in Tibetan areas then it is important that the necessary information is available to tell us how successful the approach has been in achieving project objectives. To date, there is little information available on just how successful NGO projects are.

Ultimately, improving the livelihoods of Tibetans can only be addressed by the joint actions of the government, international donors, NGOs, and Tibetans themselves working together to implement strategic development programs that will have positive and long-lasting impact. If this joint action is to be achieved it will only be on the basis of a common agenda in which all agree that Tibetan agriculture and pastoralism is an economically viable, sustainable, and worthwhile way of life. If NGOs have a contribution to make to setting the terms of this agenda rather than just responding to periodic crises (i.e., snowstorm relief) or short-term, one-off, small-scale projects it will mainly be through: (i) informing policy makers of the local, national and international economic and political processes which are at work helping to increase the vulnerability of Tibetan herders and farmers to poverty; and (ii) on the basis of the above, the design and implementation in collaboration with other donors and the government of effective pilot interventions to reduce this vulnerability in the future.

Tibetan agriculture and pastoralism has undergone profound changes in recent decades (as detailed in earlier sections of this report). Many Tibetan farmers and herders are increasingly marginalized and impoverished as a result of increasing human population on a limited productive land base, environmental deterioration, privatization of health

services, and immigration by Han Chinese which deprives Tibetans from off-farm employment opportunities. Yet, a feature of Tibetan agricultural and nomadic societies is their remarkable resilience in the face of these changes. One of the fundamental tasks of development agencies and NGOs working in Tibetan areas of China is not only to understand the nature of the changes taking place but also their implications for the kinds of technical and institutional interventions that are likely to improve the livelihoods of Tibetans in the long-term.

4.4. USAID efforts

USAID's program in Tibet for FY 02 included $1.5 million provided to The Bridge Fund, some of which has gone to support environmental and biodiversity related activities. Funds have also been used to support sustainable development related activities that address some of the economic causes of growing threats to the Tibetan plateau environment and biodiversity. The traditional Tibetan culture respects the environment and biodiversity and USAID-funded activities related to the preservation of Tibet's unique cultural heritage continue to foster environmental ethics.

For 2004-2006, the USAID Tibet program plans to support activities to promote sustainable development that will serve nomads and farmers and new forms of associations and participation in economic life. Such programs can also become vehicles to help promote public awareness of and participation in environmental policies, resource use decisions and environmental monitoring and enforcement. In addition, work with nomad and farmer groups, associations, and cooperatives will support grassroots cooperation and action that is an important basis for greater public participation in addressing environmental issues.

Much of the sustainable development work that will be funded is anticipated to be directly related to the economic causes of rangeland degradation and mismanagement of natural resources. USAID's program plans to support improved rangeland management practices, improved livestock management, and development and strengthening of rural enterprises. Activities in rural enterprise development will also potentially benefit the environment by strengthening productive and profitable enterprises that add value to livestock and agricultural products, and increase the market for livestock products, thereby potentially reducing the numbers of livestock and grazing pressure. Furthermore, improved provision of credit and financial and business services in rural areas means more opportunity for developing enterprises that provide markets for livestock products (decreasing herd sizes) and create opportunities for alternative employment and income for marginal herders and farmers and others. Perhaps more than any other industry, eco-tourism offers an opportunity for local communities and Tibet as a region to economically benefit from its special environmental and biodiversity attributes, and to increase national and local commitment to conserving these natural resources.

Activities to promote environmental conservation in protected areas and other landscapes of high biodiversity value will be of direct benefit to the Tibetan plateau environment and the conservation of biodiversity. These activities will also have global environmental

significance as many sites on the Tibetan plateau are recognized as some of the most biologically important and outstanding examples of the Earth's diverse habitats.

The economic growth side of USAID's program in Tibet will explore ways to make greater use of Tibet's comparative advantage in environmental and biodiversity values in ways that maintain these values to the fullest extent possible. The Tibetan plateau is unique in the range of ecosystems that are found on it and the relatively undisturbed status of large parts of those ecosystems. The relatively pristine nature of much of the plateau, and the rare and endangered flora and fauna that it supports, are an increasingly scarce resource in the region and internationally. From a global perspective, the value of these attributes is very high, perhaps higher than many of the commodities that Tibet could produce from them. The USAID program will undertake to convert these attributes to competitive advantage.

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