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MOUNTAINS OF THE WORLD

MOUNTAIN ECOSYSTEM DYNAMICS

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I. MOUNTAINS OF THE WORLD GENERAL OVERVIEW

1. Characteristics of Mountains

Area: mountains cover 30 million km^2 or 1/5 of global landscape

Population: close to 600 million, 1/10 of global population half of them in Andes; Himalayas; Africa

Resources: 2 billion people depend on mountains for food, hydroelectricity, timber, minerals. 1/2 of all people depend on the mountains for water (increasing scarcity of water)

Spiritual Value: mountains are more than geographical or economic entities

- Welling of gods
- Symbols of human aspiration
- Red sites (to more than 1 billion people today)

Diminishing Familiarity: mountains are unknown to a growing number of people, because of

- Urbanization
- Industrialization
- Absence of a "Jacques Cousteau" mountain advocate
- Lack of publicity similar to that for rain forests

Politically Disadvantaged: mountain regions do not have much political clout

- Dwindling populations (not in Rwanda's Virunga, Mt. Kenya, Peshawar, Papua New Guinea all of which have more than 400 persons per km^2)
- Ethnic minorities different from lowland majorities

Rich bio-Diversity:

- Mountains are not an extension of lowland ecosystems at higher elevation
- Mountains have many ecosystems all of which are distinct from lowlands
  - Elevation, slope, orientation to the sun result in large variations in temperature, radiation, wind, moisture availability and soils over short distances
  - 100 m^2 In altitude change is equivalent to 100 km change in latitude
- Mountains include the wettest place on earth- cherrapunji, India 12m of rain/yr and the driest- at Acama Desert in Chile. None in 27 years
  - Great variety in vegetation and animal life
  - In as little as 50m in altitude change, different seeds and cultivation and harvesting techniques may be necessary, Peru, Vernon.
  - One Andean farmer may plant 50 varieties of potatoes (200 exist)
  - In yunan over 500 medicinal plants are traded in local market
- Sanctuaries for plants and animals long extinct in lowlands
  - Andes are home to over 50% of neotropical bird species
  - 44% of the region's mammal species
  - 38% of its amphibians
  - In Sierra Nevada there are 10-15 thousand plant and animal species
- Mountains often thought as barren of life at high altitudes
  - This is true in temperate climates. Not true in tropics
  - A study of plant diversity found that the most diverse landscapes were areas with warm temperatures, high elevations, and large seasonal temperature variations. I.e. Tropical mountains

Extreme Vulnerability:

- Vertical dimension is the main difference and a major cause of vulnerability
- Erosion in Africa, India, Andes
- Landslides (1970 Mount Huascaran, Peru, 18,000 dead)
- Volcanic eruptions (mt. Pinatubo)
- Debris flows
- Sedimentation
- Floods

- Mountains are subject to phenomena with pronounced effects:
  - Extreme daily and seasonal variation in climate
  - Effect of gravity:
  - Loss of soil above, accumulation below.

  - Lots of moisture: rivers (1 billion Chinese, Indians, Bangladeshi get water from Himalayas)
  - Lots of erosion
  - Ecosystem recovery may take centuries
- Little attention by governments and international institutions
- Lack of knowledge
- At the margin of personal and political consciousness
- Strain on resources from over-population, as migration is not always an option.
- Intensive resource extraction
- Booming recreational use (ski, trekking, mountain biking, etc.)

2. Characteristics of Mountain Inhabitants

- Most mountainous people are relatively and absolutely poor.
- Small farmers, foragers, hunters, herders, nomads.
- Men migrate seasonally or for years.
- Men involved in cash economy, women manage household plots.
- Women are the custodians of the environment.
- Both sexes possess unique knowledge about farming and grazing methods as well as of medicinal plants.
  - In gearwheel, Himalayas national foresters could list 25 plant species destroyed by logging. A survey of local women resulted in 145 species identified.
- Most indigenous peoples live in mountains.
  - Vlachs in Greece
  - Quechua (Incas) in Peru and Bolivia
  - The "Mc coys" of the Appalachians
  - All together several thousand tribes around the world, 300-600 million people.
- Most conflicts involve mountain peoples.
- Of 34 major armed conflicts in 1993, 30 in the mountains (22 only in mountains) because of:
  - Strategic reasons
  - Border disputes
  - Enmity/discrimination toward mountainous peoples
  - Tribal conflicts

3. Economic Activities and Environmental Impacts

FARMING

TRADITIONAL VERSUS COMMERSIAL FARMING

- Indigenous traditional agriculture has sustained generations of people. Aimed to provide food and sustenance over the long term.
- Time-tested techniques upset by population increases; profit orientation.
- Today aim is to maximize yields and profits.

- Shift has been rapid before adequate and affordable measures have been identified, tested, disseminated and adopted.
- Commercial farming resulting in monoculture, intensive farming without adequate environmental measures.
- Environmental degradation, declining resources, poverty, migration as evidenced by increased landslides, diminished water supplies in irrigation systems, lower yields, longer periods for land to regenerate.
- Cuyo Cuyo, the area between Cuzco and La Paz in the Andes used to sustain significantly more people during the tiahuanaco and Inca empires than it does today. Back then they were much more adept at risk management through long-fallow shifting agriculture, multicropping and inter-cropping, and seasonal movements of livestock.
- Agronomists estimate that it would be cheaper to restore Inca terraces to farming than develop irrigated agriculture in the lowlands. But short of a totalitarian Inca system is that possible?
- Use of modern farming techniques applicable to lowlands are not suitable for mountain farming.

FARM ABANDONMENT

- Classical economic growth theory suggests some sort of progression through stages: agriculture, industry, and services.
- Through planning or spontaneously mountain peoples abandon mountain agriculture either because of migration or by changing employment. This can have significant adverse effects because farming, if done correctly, acts as a stabilizing force in a mountain's ecology.
- In the Alps where farms cultivated for thousands of years were abandoned in favor of recreational/service employment either nearby or elsewhere. In the absence of farming and before natural reforestation takes place the slopes become destabilized and are particularly susceptible to erosion, avalanches and mud slides.
- In 1992 the Swiss enacted a law to subsidize the management of pastures and forests as a less expensive (including damage to life and property) way to protect highways, railways, settlements etc. From floods, mudslides and avalanches.
- Traditional agriculture does not meet today's needs of the population. Before it is replaced abruptly and wholesale every effort should be made to integrate traditional with modern techniques.

DEFORESTRATION

- Problems occur when lands are cleared for farming at the ecological expense of forests.
- Deforestation leads to landscape instability and degradation, reduced biodiversity, loss of crop cultivars and animal breeds.
  - **Ethiopia**: farmland in or near deforested areas has been experiencing soil losses of 42 tons/ha. Twice that of nearby areas.
  - **Himalayas**: mountain farmers have been blamed for massive floods. Subsequent research points to a more complicated story. It is from extractive industries (logging and mining); non-traditional farming and poorly designed infrastructure that have caused most problems.

HERD SIZE INCREASES

OVERGRAZING - LESS CARRYING CAPACITY

- Overpopulation the main culprit.
- In central east Africa population growth has been well over 3% and often near 4%.
- In the Andes over 2.5%, doubling every 28 years.
- In Rwanda, average plot size was $17m^2$ mostly marginal hillside land.
- Immense pressure on people and animals.

OUTMIGRATION OF YOUNG MEN

- It relieves population pressure and brings in cash.
- Negative impacts: women produce, process and sell 80% of the food, run 70% of small enterprises.
- Social disruption.

LAND DISTRIBUTION

- Latifundios account for 80% of occupied land in Chile, more than 50% in Colombia, Ecuador.
- Similar disparities in Salvador (war), Mexico (chiapas), Philippines.
- Pressure to establish farms on marginal land in nearby hillsides.

DRUG PRODUCTION MOSTLY IN MOUNTAINS

- Golden triangle of southeast Asia.
- Golden crescent of Pakistan/Afghanistan, coca leaves in the Andes.
- Incomes up but also deforestation, erosion, lower soil fertility, water pollution, violence, disease, social ills.

LOGGING

- Tropical mountain forest
  - Experience very fast rate of population growth and deforestation.
  - After centuries of populations pressure in Africa most forest has disappeared.
  - Mountain people have been migrating downward.
  - In Asia, pressure has been upward, destroying existing forests in the process.
- Cloud forests.
  - Where there are persistent or frequent wind-driven clouds from which the forest can harvest atmospheric moisture. This amounts to 5-20% of normal rainfall.
  - If forests are cleared this is lost.
  - In early 70s 50 mn ha of cloud forest. Fast disappearing. In the Andes 90% gone. Others ecologically degraded by unsustainable fuelwood and charcoal cutting, commercial extraction and trade of plants and animals. Still clinging on are the mountain gorillas of Rwanda/Zaire/Uganda; the spectacled bears of the Andes; and the quetzals (long tailed bird, Aztec god) of central America.
- Temperate rain forests
- Biggest producers of biomass, 500-2000 t/ha.
  - From 40 mn ha down to 14 mn ha.
  - In Sierra Nevada erosion rates are 20-40 times higher than soil formation.

- Community involvement
  - Local communities, traditions and institutions should be strengthened and involved in the process.
  - In garwal, India: peasant women started a mini-revolution with their "hug-a-tree" movement.
  - Resulted in grass roots reforestation and a ban on commercial logging for 15 years.

WATER EXPLOITATION

- Nearly all sites in USA, Swiss Alps, Norway, New Zealand, Mexico dammed up for hydroelectricity/irrigation reservoirs.
- in spite of growing environmental issues, LDCS are racing to the same.
  - Bakun Dam in Malaysia, 2,400 mw; $5.8 billion cost; 8,000 persons dislocated, 70,000 ha inundated; 80,000 ha of tropical forest cleared for transmission lines.
  - Three gorges dam in Yangtze: 18,000 mw; $34 billion cost (est); 1.25 mn people dislocated; 110,000 ha inundated.
  - Tehri in Indian Himalayas: 260 m high dam under construction almost adjacent to where an earthquake killed over 2,000 in 1991. Protested by over 100,000 people who will lose their homes construction continues.
- World Bank under siege by ngos to stop funding dams. One in Brazil stopped another in Chile, bio bio, continues.

MINING

- Most destructive of all: habitat destruction; erosion; air pollution; acid drainage; metal contamination of water bodies.
- Glactic resources in co stopped gold mining in 1992 (bankruptcy). The mine still leaks cyanide, sulfuric acid, toxic heavy metals into 28 km of nearby Alamos river. Estimated clean-up cost $100 million.
- Ok tedi copper and gold mine in Papua New Guinea operated by Japanese is the country's second largest mine and a very important source of income.
  - The mine is at a mountain, sacred to the indigenous Wopkaimin
  - By the time the ore is used up the mountain will have been flattened.
  - The tailings (residue) were originally dumped behind a dam, which collapsed.
  - The company then got permission to dump 80,000 t directly into the river which empties into the 1,100 km fly river.
  - The tailings contain copper, cyanide, and heavy metals.
  - All fish, turtles, crocodiles and other animals and plants died for many km.
  - The water is unfit to drink or bathe in or wash clothes in.
  - River bed has risen 5 m in 10 years, destroying large areas of floodplain forest and animals that used to live there.

RECREATION

- 1898, John Muir, founder of U.S. conservation movement wrote about the nerve rattled civilized people escaping to the mountains to refresh. Now so many do it that they take the problems with them.

- mass tourism and recreation in industrial countries are outpacing mining and logging as the most destructive forces of the mountain environments.
  - great Smoky Mountains National Park is visited by 9 million each year.
  - tremendous pressure on ecosystem through non-biodegradable litter, trampled vegetation, erosion from impromptu trails for hikers, bikers, skiers and poorly planned intensive land development.
- same situation in Nepal faster growth in tourism than any country in the world.
- in the Alps
  - tourism exceeds 100 million visitor/days/year.
  - $52 billion, 250,000 jobs.
  - most of this has benefited selected areas, usually below 500m in altitude and in the broader alpine valleys.
  - communities over 1,500 m altitude have been losing population and destabilization of slopes.
- LDCS are not immune.
- in India
  - the source of the Ganges is visited by 1/4 to 1/2 million people each year, including Hindu pilgrims, trekkers, mountaineering expeditions, river rafting expeditions, campers etc.
  - forests are cut for wood and to plant foodstuffs; burn the forest for charcoal; introduce livestock.
- in Malaysia
  - cloud forests have been cleared for golf courses.
  - one medium sized course requires water which could satisfy the needs of 20,000 people.
  - golf is fastest growing type of land use in the world.
- in USA
  - ski resorts in 1993 hosted 55 million skier visits.
  - in Colorado alone, ski resorts consume 2.5 billion litres of water/year to make snow.
  - most of this in late fall and early winter when water is scarce.
  - other impacts are deforestation, erosion, population growth, land development, rising prices, property values, tax rates.
  - farmers and service workers are forced out. Aspen workers commute daily as far as 140 km one way.

4. NEW PATTERNS OF EMPLOYMENT IN MOUNTAINOUS REGIONS

- In traditional socioeconomic systems, most jobs in farming and later in extractive industries. Then, in tourism and recreation directly and in providing ancillary services indirectly.
- In the Yellowstone region of the use, over the last 20 years 96% of new jobs and 88% of new labor income was outside agriculture and extractive industries.
- Lately phenomenal growth of jobs unrelated to the local economy. This is made possible by electronic technology and ease of transport. Thus, mountains are becoming increasingly urbanized.
- Conflicts are growing between professionals, recreationalists but most of all between old intruders.

5. AIR POLUTION

- Mountains suffer from imported problems.
- Because of their vertical dimension, mountains in the proximity of urban and industrial areas intercept air pollution originating from car exhausts, heating systems and industrial operations.
  - Appalachians, the sierra Nevada range, the Alps, the Himalayas, the urals and most central European mountains are affected.
  - Since 1950, auto miles in Europe have increased 15 times.
  - Carbon monoxide missions up 5 times, hydrocarbon up 7 times, nox (nitrous oxides) 19 times.
  - 150 million drive across the Alps each year (traffic jams in both roads and trains). To go up by 50 % by 2010.
  - In 1994 st. Gothard pass residents decided that all heavy trucks will pass through on rr flatbed cars.
- Acid rain is now present in practically all continents. Greatest damage is at high altitudes where airborne acids concentrate in the clouds and on the needles or leaves of trees.

6. GREENHOUSE EFFECT

- Scientists have not established whether drop in global temperature is due to natural cycle or due to emission of greenhouse gases. Either way, a study published in 1994 sowed that over the last 100 years global temperature has gone up by 0.66 degrees c.
  - Species affected. Plants move up. Those that cannot adapt quickly (most do not) disappear.
  - Mountain cloud forests are particularly vulnerable and could quickly become desert if temperature goes up by 2 celsius.
  - Glaciers melting, water supplies disrupting agriculture, recreation, faraway urban areas (Cairo, Lima, others).

7. INVASION OF ALIENS

- Mountain ecosystems are island habitats with no defense mechanisms against invaders.
- In the past they have relied on isolation to sustain themselves.
- As accessibility increases, higher disposable incomes, transport, tastes, changing socioeconomic systems, new agents are introduced.
- These can be micro-organisms brought in unwittingly, or plants for production or ornamental purposes or animals as pets or source of food.
- Newcomers can be carriers of diseases for which local species have n defenses or they may turn out to be predators of local species. Examples: cuthroat trout population nearly wiped out by another trout species introduced a few decades ago.
- Tilapia being eaten up by Nile perch in Lake Victoria.
- How to get rid of the pests is difficult, expensive and experimental.

SELECTED COUNTRY OVERVIEW

ETHIOPIA

Highlands:

- 43% of land area
- 88% of population
- 60% of livestock
- 90% of farm land
- Water tower- Blue Nile
- 5% of highlands is forest

Problems:

- Deforestation
- Soil erosion
- Soil deterioration
- Overgrazing
- Overpopulation
- Political/social instability

Effects:

- Declining productivity; famine

Positives:

- High rainfall
- Potential for large farm production/diversity
- Potential for hydro power

Remedies:

- Slower population growth
- Socio/political stability
- Research/extension
- Eco-friendly farming systems
- Local empowerment with external support

MOROCCO

Highlands:

- Atlas mountains
- High rainfall
- Source of water, energy and labor

Problems:

- Neglect economic marginalization
- Deforestation
- Outmigration

- Changing values

Remedies:

- Afforestation
- Economic development
- Education

KENYA

Highlands:

- Over 1,500m 15% of land area
- Rainfall (most lowlands arid)
- Only remaining forests (3% of total area) water tower

Problems:

- Overpopulation (3.7%)
- Urbanization/shift to commercial farming
- Expansion up-down-slope to marginal land
- Deforestation for farming, energy

Effects:

- Soil erosion
- Sedimentation of rivers, dams, coastal reefs
- Deforestation (by 80% in last 100 years)
- Diminishing river flow (by 50% in some cases)
- High tropical forest affected little but threatened

Remedies:

- Population control
- Soil, water, forest conservation
- Farming systems
- Non-farm employment

SOUTHERN AFRICA

Highlands:

- Small % of S. Africa, vital to whole country
- Small % of Angola and Namibia, but important to both countries
- 100% of Lesotho
- Rainfall, water tower for arid, semi-arid parts
- Diverse flora and fauna
- Ancient bushman cave-rock paintings (disappearing)
- 2 mountain parks in S. Africa
- Mountain zebra
- Mountain desert (nama herdsmen use it)

- Nearby mining, agriculture, j-burg/Pretoria
- Industrial area depend on water from the mountains

Problems:

- Overpopulation
- Inappropriate farming practices
- Overstocking/overgrazing
- Drought periods destroying grass cover
- Civil war in Angola
- Apartheid/sanctions/unemployment

Effect:

- Soil erosion (Lesotho especially)
- Sedimentation
- Increased run-off and low infiltration
- Flash floods
- Invasion of alien flora species

Remedies:

- Eradication of alien species
- Re-introduction of goats to check bush expansion
- Non-farm jobs in Lesotho
- Prudent afforestation (complete forest cover detrimental to run-off reducing urban water supply)
- Soil conservation

MADAGASCAR

Highlands:

- 30% of land area
- 60% of population
- Unique flora and fauna
- Inter-mountain swamps; rice cultivation

Problems:

- Overpopulation
- Tribalism
- 50% of farms on slopes
- Deforestation
- Erosion
- Sedimentation of swamps and irrigation channels (red rivers)
- Fires
- Farm fragmentation through inheritance

Remedies:

- Coastal development
- Farming systems/commercial agriculture
- Reforestation
- Non-farm employment
- Water management
- Perennial cropping
- Family planning
- Individual land ownership
- Safeguarding of ecosystems
- Research/extension

ALPS

Features:

- 240,000 km^2; 1,000 km long; 130-250 km wide
- Deep valleys
- Alpine mountain regions no longer defined only on basis of geology but also by socioeconomic characteristics
  - Oversimplified images of:
  - Horrible mountains
  - Idyllic mountains
  - Environmental disaster mountains
  - Tremendous climatic variation
  - Four distinct vegetation zones
  - As many ecosystems as valleys
- Agriculture gave way to industry with advent of hydropower, industrial revolution.
- Small minority benefited net outmigration
- Tourism started during belle époque but small scale; mass tourism after the 1950s.

Problems:

- Intensive commercial agriculture
- Chemicals, frequent silage cutting, monoculture (hay) , flattening of hills with bulldozers
- Air pollution
- Abandoned commercial forests
- Coal/oil much cheaper than wood, old trees rotting
- Tourism; 5 million beds; 100 million visitors
- Economically weak regions
- Overuse/underuse of resources

Effect:

- Less species diversity; ecological instability
- Overgrazing in some areas/abandonment of others
- Increasing risk of erosion, avalanches, mud slides
- Intensive land use; infrastructure; traffic
- Rising land prices/taxes
- Soil/water/air pollution
- Water diverted to energy, service needs
- Manmade nature preserves (to serve tourism?)

Remedies:

- Gradual return to traditional sustainable practices already happening
- Forestry to produce wood and maintain ecological stability
- Environmental cooperation at international
  - Alpine convention of 7 countries
  - Alpine regions; integrated regional plans
- At national
  - Alpine working groups
- At communal levels
  - Few communal master plans developed

THE HIMALAYAS

- "The land of snow and ice" abode of hindu gods
- 3.4 million km^2
- Spread over 8 countries
- Super water tower
- Flora diversity giving rise to whole medical systems, e.g. Ayurveda, Yunani, Tibetan

Problems:

- Recent economic development based on logging, sale of medicinal plants, mining, exploitation of water resources, tourism, commercial farming, urbanization of foothills
- Road/air transport integrated the mountain and lowland economies, cultures and aspirations
- Exploitation of resources reached unprecedented levels
- Economies of scale for profit are diseconomies of scale for the environment
- Overpopulation
- Consumerism
- Development efforts to halt deterioration had opposite effect

Effects:

- Deforestation
- Soil degradation and erosion (mining, logging)

- Overgrazing
- River dams
- Sedimentation of huge proportions
- Pollution, waste, garbage,
- 1970's Bangladesh floods

Remedies:

- Agriculture: productivity; crop diversification; research; t & v; services to farmers
- Horticulture: integrated development; infrastructure; marketing; introduce expand mushroom bee keeping; credit
- Soil and water conservation: protect land; reduce erosion; reclaim denuded land; watershed management through mullet-disciplinary approach
- Animal husbandry: increased productivity, reduce load to carrying capacity; expand daring
- Forestry: regenerate ecology; provide fuel, fodder and timber, subsidiary forest products (fruit, nuts, silkworm); afforestation, management
- Irrigation and flood control: through small schemes
- Power generation: through small projects
- Mining: subject to strict controls and regulations
- Roads and bridges: priority to secondary roads and paths
- Tourism: determine the physical and biological carrying capacity; establish recreation zones of varying intensities; limit visitors
- Education and training: to control of environmental degradation
- Establishment and enforcement of environmental laws;
- Community participation
- Plan: for ecological management of development

THE PYRES

- At French Spanish border
- About 500km long

Problems:

- Depopulation
- Abandonment of agricultural land, changing flora
- Water diverted to hydro, urban uses
- Tourism growth
- Farmers have become service workers (negative correlation between hotel vacancies and livestock breeding)
- Political instability, non-communication

Effects:

- Soil erosion
- Deforestation

- Air pollution
- Solid waste proliferation

Remedies:

- Traditional farming systems
- Managed reforestation
- Pollution control
- Cross-boundary programs
- Education/training

MOUNTAIN ECOSYSTEM DYNAMICS: NEPAL AND SWITZERLAND COMPARED

1. The two situations: similar yet different

- Both ecosystems are under pressure from their respective human populations.
- Problems and mechanisms involved are simultaneously different and analogous.
- Important highland-lowland interaction in Nepal and the Swiss Alps.
- In Nepal, strong ecological and relatively weak economic interactions. The dominant ecological effects are from the highlands towards the lowlands.
- In the Swiss Alps, strong primary economic interactions, leading to secondary ecological repercussions in the highlands. The driving forces emanate from the urban and industrialized centers in the lowlands.

2. Major features of systems dynamics in Nepal

- In Nepal a number of natural resources are threatened.
  - The most important are forests as a source of energy and ecological stabilization
  - Fertile agricultural land for food and fertilizer production.
  - Forest and pasture fertility for fodder and compost production.
  - Water in the dry season for irrigation and domestic uses.
- Highland-lowland interactions are dominated by the potential effects of population in the highlands.
  - The dominating mechanism is the conflict between an increasing number of people at a minimal standard of living and the limited local resources.
  - The quest for food, wood for fuel, fodder, and water must be balanced with the regenerative capacity of the land.
- Negative feedbacks, such as hunger and impaired health, affect the per capita production and consumption, and population growth.
- The situation is aggravated by socio-cultural, political, economic factors, and government intervention.

3. Major features of systems dynamics in Switzerland

- Pressure on the ecological stability derive from economic growth, high levels of production and consumption and technology, rather than population.

- The utilization, and sometimes exploitation, of untouched landscapes as recreational resources (or as an economic resource in the case of tourism) threatens mountain agriculture and economics, which themselves are a precondition for mountain ecological stability.
- Highland-lowland interactions are dominated by the activities of people in the lowland urban centers.
- Deteriorating tourism because of impaired environmental quality and overcrowding.
- The essential driving mechanism is the continued growth of industrial productivity, stemming in part from constant societal values in the education system, as well as in scientific and technical research and development.
- Increased industrial productivity, in turn, forces increased agricultural productivity, but lowland agriculture is more of a business, leading to increasing economic disparities between highland and lowland farming, thereby causing greater economic and ecological instability in the highlands.

4. Common factors with different significance in Nepal and Switzerland

- Comparing the two sets of mechanisms just described, one fundamental difference.
  - Alpine mountains threatened by economic wealth and technological potency.
  - Himalayan mountains threatened by economic poverty and demographic growth.
- Economic-ecological systems dynamics can be portrayed in a function which relates the macro-interrelationships between the human activity system (population, affluence and technology), the quality and productivity of the natural environment, and the economic-ecological import-export relationships of the system with the rest of the world.
- Ecological stability or instability as determined by the balance between population, affluence, and the efficiency of technology on the one hand, and the regenerative environmental capacity and import or export of such capacity on the other.

  (P x A x T) - (C + 1-E) env

  Where

  P = population

  A = affluence, or material standard of living

  T = technology

  C = environmental regenerative capacity

  I, E = import and export, respectively, of environmental resources of regenerative capacity.
- With regard to energy, Switzerland imports oil, gas, and uranium, the total of which is equivalent to some 2,000 kg of oil or 7,000 kg of wood per person.
- This is approximately 20 times the per capita energy consumption of Nepal, where the deficit of a few hundred kilograms of wood is minimal in comparison with Switzerland.
- Yet it is very significant in terms of Nepal's regional energy balance, as it amounts to some 30-40 per cent of the regenerative capacity of the local forests.
- Switzerland and Nepal have very similar protection-oriented forest laws.
  - In Switzerland, the forest area has remained constant; in Nepal, the forests are being destroyed.
- The situation is quite similar with regard to food.

- Food production deficit in Switzerland is of the order of a few thousands kilocalories per capita per day expressed in terms of grain calories needed to produce the meat-oriented diet customary in Switzerland.
- This deficit is balanced by imports while Nepal's deficit — at a much lower standard — results in malnutrition and hunger.

IS THERE A HOPE?

1. Review

Mountains are

- Water reservoirs for human consumption
- Weather makers for most of the world
- Source of biological diversity
- Spiritual, sacred places
- Recreation sites

Mountains threatened by natural and human forces

- Poverty, higher cost of living, limited services, low education
- Little political influence
- Limited information, bias against mountain people
- Natural calamities
- Mountain people marginalized while mountain resources integrated, haphazardly, into lowland economy
- Minerals, hydro-power
- Agriculture, logging: disaster if done wrong; remedies if done right
- Economic activities with disastrous side effects
- Climate change/ global warming

Sustainable development: three feasible actions

- Greater involvement by mountainous people with support from local, international organizations
- Create mountain constituency
- Institutional development of local, regional, international supporters

2. MAB research in Europe

MAB: man and the biosphere. An offshoot of the biosphere conference held in Paris in 1968. MAB was undertaken in 1970, sponsored by UNESCO. Review of MAB projects for Europe undertaken in 1992-1995.

AUSTRIA

Obergurgl village in Tyrol: development of an integrated model-based approach to analyzing and understanding alpine environments.

- demonstrated the need for collaboration between those living in and those studying an area.

- utilization of the findings in developing a regional plan. For example, a quiet area was delineated where tourist development is banned but traditional agriculture is encouraged.

Grossglockner: studies of small birds; vegetation; alpine pastures;; impacts of heavy metal and air pollution; development of topographic maps. Overall results not yet published.

Gastein: research on alpine pastures; hydrology; forests; impact of skiing; methodology of environmental assessment of ski resorts.

Sameralm: climate, geology, socio-economic changes, vegetation, alpine farming, soil erosion, deforestation, humidity, pastureland.

- research provided important findings in all areas studied.
- main criticism is that with the exception of obergugl none followed an integrated approach. It was individual studies that happened to be implemented at the same time.
- little follow-up in terms of policy or action.

BULGARIA

Pirin: limited research on pine forests and wild flowers.

Rhodopi: forest genetics, entomology and pathogens. More recently on conflicts between tourism and nature protection.

Rila: extensive forest research.

Stara planina: mostly on forests but also on mammals, birds, geology and soil composition and erosion.

CZECH REPUBLIC

Giant mountains: massive air pollution from Poland, Germany, Czech Republic.

- growing tourism and recreation.
- research started in 1607 and has grown ever since. None of it interdisciplinary.
- most recently a joint Dutch-Czech effort to study reconstruction of forests damaged by air pollution.

Sumac: adjoining the Bavarian forest in Germany and Austria. A lot of research by the latter two but constrained on Czech side by cold war security concerns.

FRANCE

Pyrenees: effect on human activities on mountain ecosystems.

Pre-Alps: development of integrated production systems linking sheep-raising with diversified crop production and improved forest resources. Pastoral management to improve forage on grazing land.

Alps: management of high mountains and environmental consequences.

Massif central: establish an observatory of ecological, social and economic changes. Subsequent research dealt with biological diversity, farm systems, transferability of results, forest management and the impact of livestock on forest regeneration.

GERMANY

Berchtesgaden Alps of Bavaria. Developed a set of plausible development scenarios and then studied each one with regard to its impacts on the socio-economic and environmental aspects of the area. Methodologies for similar research in many parts of the world, including China and Israel. In

Bavaria, results are now being incorporated in a master plan for the management of national parks and biosphere reserves.

POLAND

Babia gora: research going on for two centuries. Most recently focused on forests, the accumulation of heavy metals in the soil and vegetation, entomology, and tourism.

Bieszcady: recent research has focused on mammals, stream invertebrates, vegetation and scenarios fro tourism development.

Giant Mountains: climatological data exists since 1824 and for many other parameters since 1881. Recent research has focused on forests and entomology (insects are rapid indicators of ecological change), mammal populations, phytosociology, hydrology, air pollution and tourism. Research findings were instrumental in the design of a World Bank funded project to promote forest bio-diversity.

Tatras: a great deal of research on the tatras for a couple of centuries. 300-400 scientists working on 100 projects register each year to do research there since the early 80s. Registration renewals require written summaries of the previous year's research leading to a huge collection of written findings. Both short and long term efforts covering the whole spectrum of mountain issues.

SLOVAKIA

High Tatras: research on-going for centuries but little inter-disciplinary. In 1992 program started to assess and manage antropogenic stresses. Not much progress because of lack of funds but some progress on effect of acid rain and survey of watersheds.

Eastern Carpathians: research mostly related to forests but also on geology and hydrology above timberline.

SPAIN

Western high aragon: a multidisciplinary study of the resources of the whole region to be used in subsequent plan and policy formulation. Parallel studies looked at pine forests, wildlife, livestock, and the impact on the environment of socio-economic change. No discernible impact on policy.

High Catalanpyrenees: research aiming to develop a full understanding of the state of the region through a series of linked studies. Over 100 papers produced on four main themes: background information, demography, land use, and infrastructure. A number of policies/actions resulted from this work at the local and regional level with respect to infrastructure development, tourism, fire prevention and control, and natural park development

SWITZERLAND

Aletsch: mostly research on natural scientific themes but also some on socioeconomic systems, agriculture and landscape quality. The results were incorporated into regional master plans for resort development.

Davos: biophysical environment and human influences with respect to soils, forests, vegetation, wildlife, land use, and avalanche hazards.

- little interest among public until results showed considerable air pollution.
- recognition of importance of agriculture.
- elements incorporated in Davos' master plan.

Grindelwald: research in environmental modeling, hydrology, air quality, wildlife, forests, agriculture, land use, labor patterns, effects of tourism, traffic. Also, environmental assessment of winter Olympics.

- local people were involved through discussions of intermediate findings.
- main conclusion was that tourism should be developed in a qualitative direction, and that a balance should be found between old and new residents.
- findings were incorporated in master plan regulating land use, second home construction and ownership (40% reserved for locals), new transport plan emphasizing public transport, and revival of agriculture and cultural preservation.

Pays d' Enhaut: quantitative models (lp and dynamic balance) used to study agriculture, demographics and economies, forestry, land use and nature protection, society and environment, tourism.

- local people involved throughout the process.
- research findings had broad impact on many policies not only in Switzerland but elsewhere including the Pyrenees.
- some of the models used in Switzerland are replications or refinements of those developed earlier in Kenya and dealing with multiple economic activities.

USSR (FORMER)

Altai Sayan (at the junction of Mongolia, China, Kazakstan and Russia): research mostly on climatology, natural hazards, and the use of glacial resources for water and recreation.

Carpathians-Crimea: forest ecosystems, water resources, nature protection, chemical composition of rainfall and recreation impact on forests. One concrete outcome was a detailed proposal for a biosphere reserve in the eastern Carpathians across the Polish, Slovakian and Ukrainian border.

Caucasus: formation of geosystems, land use and protection of natural resources, prevention of natural hazards, socio-economic processes, demographics, productivity of mountain meadows, protective function of forests, multiple uses of forests. Most work concentrated in the then republics of Armenia, Georgia, Azerbaijan and Tajikistan. Since break-up of USSR work has ceased.

Tien Shan (Kyrgyzstan): water resources, soils, vegetation, forests, agriculture, power stations and recreation.

- related work in Tajikistan, Turkmenistan and Uzbekistan.
- little of this primary research synthesized and published.

Siberia and the Far East: glaciology, zoology, environmental impact assessment of industrial projects, nature protection. Little of this research has been synthesized.

Urals: in the north focus on the effects of agriculture, recreation and industrial pollution on meadow vegetation and animals.

- in the south, focus on the formation and management of forest ecosystems.
- little synthesis of the research although some calls have been made for the establishment of reserves to protect endangered species and ecosystems.

3. Environmental protection

PARKS

First one when New Zealand's Maori, in the face of encroachment by sheep farmers and other colonists, gave their sacred tongariro mountains to Queen Victoria as a gift.

8% of world's mountains are under some form of protection. 243 million ha. However, about 40% of them, 97 million ha, consists of the greenland national park.

Uneven distribution. 2.6% of Swiss Alps; 70% of New Zealand's southern Alps. Protection enforcement is very uneven. Many mountains not protected at all.

Even in developed countries parks are viewed primarily as recreation sites and secondarily as wilderness preserves. Grizzly population in southern Canadian rockies have declined primarily because their home area has been squeezed by the millions of visitors.

In centinela forest preserve of Ecuador 90 previously unidentified species of plants had been found. The forest was wiped out by illegal logging.

It is now a known fact that as biodiversity declines plants are more susceptible to disease and drought.

In many cases, protected areas include only the rocky promontories not the biologically rich habitats of lower altitudes.

MABS (UNESCO'S MAN AND THE BIOSPHERE PROGRAM)

More compatible with densely populated areas.

A biosphere reserve has 3 areas. The core area is the most strictly protected, often an existing park or preserve.

Ringed by a buffer area where low-impact activities are allowed. Research, education, traditional agriculture, renewable resource extraction.

Outside the buffer is a transition zone for human settlements and a wide range of economic activity.

In practice, mabs have not been fully implemented and even where they exist on paper, restrictions have not been enforced.

ADDRESSING THE OWNERSHIP QUESTION: WHOSE MOUNTAINS ARE THEY ANYWAY?

- Who is the owner?
- The world
- The nation
- The region
- The mountain's inhabitants

Regardless of who the owner is, unless the inhabitants take an active interest, nothing positive will happen. Several projects involving local people early on, that is in the design as well as the implementation of the project have shown promising results.

AMAPURNA REGION, NEPAL

- 763,000 ha; 120,000 people; 14 ethnic groups; from subtropical lowlands to dry alpine steppe; 1,422 plant species including 100 species of orchids; 474 bird species; 101 mammal species.

- main problem stems from 50,000 trekkers plus an equal number of porters ascending the trail each year.
- local population growing by 2.9%/year.

Forests are being depleted causing problems for traditional farmers (90% of the residents) as soils are eroded at 20-50 t/ha each year.

Project priorities were defined by the locals: clean water and adequate health care. Resource management was next.

- Community forest management
- Tree nurseries
- Fodder and fuel plantations
- Training for farmers and for lodge managers
- Establishment of land use zones (strict conservation, low impact use, intensive use).
- Switch from wood to kerosene (saving 1,600 kg of wood/day)
- Subsequent programs for
- Family planning
- Literacy for women and children

LA ARMISTAD BIOSPHERE RESERVE

- Straddles Costa Rica and Panama.
- 1.5 million ha; largest tropical cloud forest in central America; supplies half of Costa Rica's water.
- Species include 10,000 plants, 400 birds, 250 reptiles and amphibians, six tropical cats.
- Home to four indigenous cultures.
- Land around the reserve is used for plantation agriculture, mining, ranching and small-scale farming.
- Land pressure is forcing immigrants onto the reserve, even the core area.

In 1994, a partnership was formed by McDonalts, Conservation International, Clemson U. And 80 local families. The partnership established a micro-lending, community based bank to help small farmers. Identifies projects for the locals, e.g. Naranjilla production for fruit juice, naranjilla trees are environmentally friendly and helps other plants grow under its canopy. Scholarships and training in forestry, soil conservation, extension. Extend the program to the Panama side.

FUNDACION SIERRA NEVADA DE SANTA MARIA

The world's greatest massif is near the Caribbean coast of Colombia. Within 42 km of the coast altitude reaches 5,775 m.

- the range covers 17,000 km^2.
- 30,000 people of several tribes, 150,000 immigrant peasants, several guerrilla groups, paramilitary organizations, army units, and a flourishing narcotics industry.
- thousands of plant and animal species and several hundred found nowhere else in the world.
- Administratively the Sierra is fragmented into 3 districts, 10 municipalities, 35 government agencies, 2 national parks and 2 reserves.
  - Rivers from the Sierra provide water to 1,5 million people.
  - Hundreds of thousands of forest have been destroyed for farming, grazing and drug production.

- Marijuana alone accounts for over 100,000 ha of cleared forest.

The project started by concentrating on raising environmental awareness and building a consensus among the different, and often warring, parties, administrative entities, ethnic and various interest groups.

Important to let everyone know what the foundation staff were doing, lest they be suspected of drug trafficking or drug enforcement, or guerrilla or counter-guerrilla activity.

- The foundation has managed to:
  - Gather vital data on land use, existing resources, and other base line information.
  - Establish community education centers to teach proper terracing and other erosion control measures, irrigation, farming, aquaculture etc.
  - Promote literacy and health care campaigns.
  - Establish a working group of all ten municipalities to coordinate conservation work.
  - Return 19,000 ha of land illegally occupied by immigrants to the indigenous kogi tribe.
- Income earners
- No incentives for locals, although changing
- Population pressures
- Growing tourism
- Infrastructure
- Crime
- Poaching/corruption in both developed and developing countries

4. What is the record of the community-based initiatives?

- Frequent confusion between development and conservation objectives.
- By choice or by accident, development objectives are pursued to the exclusion of conservation in 5 of 36 projects reviewed.
- Long-term commitment of people and money is necessary.
- Perfect is the enemy of good.
- Complete consensus is impossible to achieve; majority rules but active minorities decide.
- Community participation is necessary to gather information, design action plans and implement them. At the same time policies and funding from higher level are also necessary.

ANALYTICAL TECHNIQUES

1. Need for integrated approach because of complex mountain ecosystems

- Geology
- Meteorology
- Sociology
- Agricultural sciences
- Economics
- Environmental sciences

2. Generalized model of mountain ecosystem dynamics

- generalized models of mountain ecosystems have been developed, following the systems approach to help achieve rational, integrated mountain development.
- the simplified systems approach can be used to define and evaluate key processes that endanger the present and future stability of the mountain ecosystems.
- this permits the adoption of appropriate measures so that development of rational land-use alternatives can more easily follow.
- relations between subsystems illustrate the limiting factors of one subsystem on the other.

Relief and soil quality, as elements of the subsystem nature, limit agricultural activities, shown as elements in the land use subsystem.

Human activities included in the subsystem man are limited through harvest reductions or losses, resulting in out-migration or the introduction of conservation measures.

This linear set of relationships extends into the external subsystem by limiting external interests through a reduction 1n trade, or even political unrest.

Relationships between subsystems are the critical processes endangering the stability of the entire geoecosystem.

Road construction work, hillside terracing campaigns, and the development of tourism may provide jobs, but these developments may not have a significant impact on the prevailing subsistence agriculture in developing countries.

Other key processes, such as the progressive extension of cultivated land, soil erosion, and developing tourism may prove to be critical in destabilizing the geoecosystem.

3 . Objectives and strategies for the management of mountain ecosystems

Protective. Soil, forest, water and other natural resources present in the ecosystem.

Regeneration of resources. Restoration of forest and grass cover, the realization of agricultural potentials by intensive means, the effective use of forest resources and the development of human knowledge and skills.

Productive. Deployment of natural resources along with human skills, to enhance the productivity of the economic unit and local employment and local incomes.

Suitable technologies need to be developed together with training and extension services according to local needs efforts, with a view to bringing about a constructively meaningful relationship between the land and the laboratory.

The basic strategy being "development without destruction", the following measures are proposed as guidelines for the integrated management of mountain ecosystems:

(a) correct land use

- Soil stability and fertility.
- Water conservation.
- Steeper slopes under perennial shrubs, trees, plantations and pastures.
- Unirrigated areas to be put under scientific dry land farming and forests developed for both production and environmental security.

(b) integrated micro-watershed management.

- inter-sectoral linkages and an effective multidisciplinary

- Approach with suitable delineation of unit areas for socio-economic. Development, namely, catchments, sub-catchments and micro- Catchments as eco-units.
- administrative boundaries same as natural boundaries to help. Effective management of mountain ecosystems.

(c) afforestation combined with effective grazing regulations.

(d) development of alternate sources of energy to assist afforestation and preserve forest cover.coordinated scheme for bio-fuel plantation combined with Development of micro-hydroelectric energy and other alternative Forms of energy.

(e) progressive reduction of the incidence of poverty with Stress on family-oriented programmes maximizing local Employment to reduce out-migration.

(f) consolidate gains from productive activities and correct imbalances in investment in the productive sectors and basic infrastructural and social facilities on the other.

(g) resource-based industries where pollution problems are manageable, should be encouraged, with preference being given to non-polluting industries. small and cottage industries whose products have high value and low volume, electronics, optics, light engineering goods. woolens. handicrafts and sericulture are examples.

(h) harness power potential, especially micro-hydroelectric generation and rural electrification. the rural electrification programme needs to be accelerated with subsidized electricity so that pressure on the hill forests is contained.

(i) growth centers at the local level should be established easily accessible to the rural population, to provide at a single point, the necessary inputs for production and consumption, like fertilizers, pesticides, storage godowns, credit and marketing facilities.

(j) herds should be limited and livestock populations, which should be progressively stall-fed, should be improved. Dairying and milk supply programmes should be developed and coordinated efforts made to improve their quality by supply the necessary inputs, linkages and organizational support.

(k) tourism should be developed keeping 1n view its social and ecological impact on the mountain ecosystem.

(l) qualitative improvement in education, developing local skills through job-oriented technical training suitable for the hills and diversifying training courses to meet the growing manpower needs of existing and new industries planned for the areas.

(m) rural roads should be developed through a mix of arterial roads, link roads, bridle paths and foot-bridges, linking road programmes with economic activities in agriculture, horticulture, and tourism and basic amenities in public health, etc.

(n) the administrative framework needs reorganizing, strengthening co-operative structures and building institutions, so maximizing the people's participation in development:

(o) an action-oriented research base needs developing, evaluating, monitoring and feed-back. universities, research institutions and technology transfer organizations should be involved in the identification of problems and problem-solving

(p) suitable technologies need to be developed together with training and extension services according to local needs efforts, with a view to bringing about a constructively meaningful relationship between the land and the laboratory.

(q) spring sanctuaries need to be created to regenerate the drying springs and supply potable drinking water.

(r) women should be directly involved in the planning, implementation and operation of programmes and projects that are of their immediate concern, namely: fuel, fodder, timber, drinking water, family welfare and planning, agricultural extension and livestock management

4. Environmental impact assessment and elements of project analysis

ENVIRONMENTAL ASSESSMENT AND THE PROJECT CYCLE

PROJECT APPRAISAL WITH AND WITHOUT ENVIRONMENTAL IMPACTS (ei)

The main differences are:

- Extending the physical input-output table in time and space using an environmental assessment.
- Extending the economic analysis by shadow pricing inputs and outputs to account not only for policy failures but also for market and institutional failures.
- Comparing benefit/cost with new criteria (annuity or periodic) using a real long-term discount rate and a long or indefinite time span.
- Comparing projects with different objectives through real participation.

Steps in project analysis	Without ei	With ei
1. I/O	Direct production.	Production function plus an environmental assessment (expand the physical analysis in space and time).
2. Valuation	Market prices or shadow prices correcting mostly For policy failure.	Shadow prices rectifying for policy but also market and institutional failures.
3. B/C	Use NPV, IRR, B/C criteria together with risk analysis.	Mostly new kind of criteria, but also cost effectiveness, with real long-term rate of discount and often an unlimited time span, together with uncertainty analysis.
4. Decision making	Mostly efficiency objective.	Efficiency plus social and environmental objectives balanced through participation.

- the worth of a project has to take into consideration the opportunity cost of the resources used.
- the economic impact of a project is the difference in present value between the with and without project alternative.
- the with-without project situation should not be confused with a before-after situation.

MAIN DIFFERENCES BETWEEN FINANCIAL AND ECONOMIC ANALYSIS

	Financial analysis	Economic analysis
Point of view	Net returns to equity capital or to private group or individual.	Net returns to society.
Purposes	Indication of incentive to adopt or implement.	Determine if government investment is justified on economic efficiency basis.
Prices	Market or administered (may assume that markets are perfect or that administered prices have compensated for imperfections).	May require "shadow prices" (e.g., Monopoly in markets, external effects, unemployed or underemployed factors, over-valued currency).
Taxes	Cost of production	Part of total societal benefits.
Subsidies	Source of revenue	Part of total societal cost.
Loans	Increase capital resources available.	A transfer payment; transfers a claim to resource flow.
Interest or loan repayment	A financial cost; decreases Capital resources available.	A transfer payment.
Discount rate	Marginal cost of money; market borrowing rate.	Opportunity cost of capital; social time preference rate.
Income distribution	Can be measured re: net returns to individual factors or production such as land, labor, and capital.	Is not considered in economic efficiency analysis. Can be done as separate analysis or as weighted efficiency analysis.

The economic value represents consumers' willingness to pay (wtp). A perfectly competitive market provides the right values of goods and services in that market, given existing polices affecting wtp. In the case of input values or costs, opportunity cost is used— i.e., The value forgone by not being able to use the input in its next best alternative and it is measured in terms of consumers' wtp for the goods and/or service forgone. So, for both inputs and outputs, wtp is the basis for valuation in economic analysis. in practical terms, the actual market prices, sometimes local, often international, are taken as a good approximation of economic values.

Shadow prices are calculated depending on how much economic polices are distorted and the importance of the value of an input or output in the project. Economic cash flows ignore transfer payments. In environmental economics, many costs and benefits are evaluated at the global level. Even interest on a loan paid outside a country is considered a transfer payment. A subsidy on land clearing speeds up deforestation, but on kerosene it can slow down fuelwood harvesting.

SOCIAL COST VALUATION METHODS

For welfare losses that cannot be directly calculated from market prices, several techniques have been developed to approximate social welfare losses from pollution. Commonly used valuation techniques are briefly presented below.

Damage cost valuation
Reduction in income based on product market prices, increase of medical costs and indirect costs from illness. Dose-response functions relate the responses to pollutant concentrations, and the concentrations are calculated from emission amounts and dispersion studies. Example: SO_2 and NO_x particle emissions which affect health, crop yield, forest growth, material damage and others.

Reduction cost valuation
Costs of emission reduction or costs of shadow projects (shadow projects are alternative measures to reduce emissions to the same recipient). Example: national or regional evaluations of total and marginal costs to meet internationally agreed pollution reduction goals.

Avertive expenditures
Expenditures for substitutes or complements to compensate for effects of pollution on "victims" of pollution. Example: noise abatement using insulation, cost to farmers of more land or extra fertilizer to compensate for reduced crop yield.

Travel cost method
Travel expenditures to reach a recreational site indicate its value to Society.

Hedonic pricing methods
Prices of marketed goods, e.g. Housing, influenced by the presence of non-marketed goods, e.g. Pollution. in such cases, valuation can be based on the effect of the state of the environment on property prices.

Experimental methods
Field studies of society's willingness to pay (wtp) for environmental improvement, or willingness to accept (wta) compensation for environmental damage. Examples: wtp to avoid chronic or acute illness, wtp to preserve endangered species.

Legal liability
Damage penalities paid according to law enforcement can gave indications of the value to society of environmental quality.

DISCOUNT RATE AND COMPARISON OF COSTS AND BENEFITS

To compare the benefits and costs of an investment over time, the discount rate is crucial.

The greatest difference between financial and economic analysis usually occurs because of the discount rate. The appropriate discount rate to use for an economic analysis, especially where the project has environmental impacts, is a controversial topic.

The value of environmental goods as they become scarcer should appreciate accordingly. The relative price increase of environmental goods and services over time will have to be properly reflected in the cash flow table.

The discount rate used for the economic analysis of projects with environmental impacts is the same as without these impacts, but both are different from the rate used in the financial analysis in which only the opportunity cost of capital is considered.

The rate of social time preference still needs to be determined and cannot be derived from an aggregation of individuals' market- revealed time preference since private and collective time preference are two different things.

People may be ready to sacrifice for future generations if others would be prepared to do the same.

One is left with the political process to establish the social time preference. It is assumed that the policy maker's goal is to transfer to the next generation a resource base equivalent to that of 1= present generation' s. One way to do so, is to set r as an unknown to the equation:

$$NPW = \sum_{T=O}^{\infty} \frac{BtCt}{(1+r)^t} - aK_o$$

Bt and **ct** = social benefits and costs in year t.

r = social discount rate

k = capital invested 1n year o

a = opportunity cost per $ of public investment (private iforegone).

Repeated decisions for some kind of projects with specific environmental impacts would imply a range of social discount rates which eventually could serve as a guide for future decisions concerning similar projects.

All the values in the cash flow tables, financial as well as economic, should be in real terms.

Only the real (not nominal) r and p (private sector opportunity cost of k) should be considered.

The difference between a real and nominal discount rate is important for long-term environmental impacts to be valued and discounted. The appropriate relationship between nominal and real rates of discount is a multiplicative one:

(l+n) = (l+f)(l+r)

when n = nominal (inflated discount rate)

r = real discount rate

f = average annual percentage rate of inflation

If a nominal rate of discount is used without valuing environmental benefits including an inflation factor, it will bias the analysis against projects with positive environmental impacts.

Only real price increases in environmental goods and services have to be estimated.

Total discounted incremental costs and benefits for Kunda Cement Factory in Estonia	
Costs/benefits	**Present value* (US$ million)**
Costs	
Capital	8.00
Operating	3 55
Total costs	11.55
Benefits	
Raw materials	4.86
Personnel turnover	0.17
Soiling reduction	2.42
Real estate values	5.50
Health improvement	3.09
Agriculture and forestry	1.17
Tourism receipts	2.22
SO_2/NO_x reduction	6.78
Total benefits	26.21
Economic rate of return (ERR)	24.7%
* 10 percent rate of discount	

PRESENT VALUE AND BENEFICIARIES OF ENVIRONMENTAL INVESTMENTS (US$ MILLION) KUNDA CEMENT FACTORY		
Impact	PV	Beneficiaries
Forestry and agriculture	1.17	Forest owners and farmers within 5 km radius
Raw materials/ Employee turnover*	1.48	KNC
Increased tourism	2.22	Enterprises and employees in Kunda region
Reduced soiling and material damages	2.42	Kunda residents
Reduced health care costs	3.09	KNC workers and Kunda residents
Real estate values	5.50	Real estate owners in Kunda
Less damage from SO_2, No_x emissions	6.78	Inhabitants of European countries near Estonia

VI. AGENDA FOR THE FUTURE

ENSURE REPRESENTATION AND PARTICIPATION OF MOUNTAIN PEOPLES ALREADY STARTED IN SMALL WAY, NEEDS TO BE EXPANDED

NATIONAL AND INTERNATIONAL AGENCIES TO ENSURE:

- Secure local control over land and other resources.
  - Land distribution, access rights, environmental assessments, recognition of ancestral homelands.
- Reduce impacts of livestock, timber, hydropower, mining, recreation.
  - Improve efficiency of use of timber, ores, kw produced to eliminate waste.
  - Recycling, elimination of subsidies, price natural resources at their full, present and future (replacement) cost, economic and social.
  - Market environmentally produced goods at a premium.
  - Tax consumption of virgin materials and resources and return a portion of the proceeds to the local communities affected.
  - Establish tax credits for land donations. Debt for conservation swaps.
  - Downscale extractive operations in fragile ecosystems.
  - Instead of mega-dams establish more small dams that the environment can cope with.
- Create regional conservation networks.
  - Mountains, because of their inaccessibility are best suited for this purpose.
  - In North America, proponents of this plan call for the core conservation areas to be in the rockies and the appalachians moving along the andes down to south america.
  - These core areas would be connected with conservation corridors. How much chance is there for something like this happening?
  - The mountain institute, based in West Virginia, has worked with the Nepalese and Chinese governments to create two multiple-use conservation areas that adjoin three existing Nepalese national parks.
  - All together they comprise over 4.1 million ha, larger than Switzerland. Over 100,000 inhabitants.
- Improve knowledge through research, monitoring, education.
  - Data is extremely scarce.
  - Where it exists it is one-sided. Very few inter-disciplinary efforts.
  - One is the African Mountain association's Mount Kenya Ecological Programme, another, the International Potato Center's Sustainable Andean Development Project. And the third the Biosphere Project in the Alps.
- Establish institutions and cooperative agreements for each major range.
  - Need to develop institutional mechanisms spanning national borders. Andes, Alps across seven countries; Himalayas across eight.
  - A beginning has been made with the Alpine Convention and the International Centre for Integrated Mountain Development to promote sustainable development through education, scientific training, development specialists, extension workers, research.
  - Integrate mountains into development projects and policies.
  - In general, mountains are low on the agenda, if at all.

- Of approximately 1,600 World Bank projects over the last 6 years or so, only 13 dealt explicitly with improving the lives of mountain peoples.
- In terms of money, $493 out of $151 billion, 0.3% of the total was for mountain-dedicated projects.
- Other multilaterals about the same, except IFAD which dedicated 40% of its Asian projects and 70% of its Latin American projects to alleviating poverty in mountainous regions.
- Environment now a much more central consideration in the World Bank.
- NGOs are also very active, dispersing about $6 billion annually. However, a small percentage is dedicated to mountainous regions.
- GEF deals with biodiversity, climate change and international water issues. All very relevant to mountains.

• Private sector involvement.

- Private sector can and has played an important role. NEFCOH's environmental fund, funding by many large and small companies for environmental projects.
- Is it too late?

• Green accounting.

- There is a need to re-think our values away from consumption and emphasis on gap measured growth if the ecology has any chance of survival.

Mountain Glacier Retreat, Selected Regions

Region	Number of Glaciers	Period of Observation	Scaled Mean Trend[1]
Alps	4	1850–1988	-9.3
Central Asia	9	1874–1980	-13.3
Iceland	1	1850–1965	-6 3
Irian Jaya	2	1836–1990	-7.1
Kenya	2	1893– 1987	-6.7
New Zealand	1	1894–1990	-13.9
Norway	2	1850–1990	-12.1
Rocky Mountains	24	1890–1974	-13.7
Spitsbergen	3	1906–1990	-14. 9

The records for different glaciers were made comparable by a two-step scaling procedure that compensated for differences in glacier geometry and in climate sensitivity.

Source: Adapted from Johannes Oerlemans, "Quantifying Global Warming from the Retreat of Glaciers," *Science*, April 8,1994.

Tropical Population, Forest Cover, and Forest Loss, 1981-1990				
Primary Forest Ecosystem Type	Population Density 1990	Forest Cover 1990	Population Growth 1981-90	Forest Loss 1981-90
	People per Square Kilometer	Million Hectares	Percent Annual Change	Percent Annual Change
Hill and Mountain	56	204.3	2.6	1.1
Lowland Rainforest	41	718.3	2.2	0.6
Lowland Moist Deciduous	55	587.3	2.4	1.0
Lowland Dry and Very Dry	70	238.3	2.3	0.9

Source: Adapted from Food and Agriculture Organization (FAO) of the United Nations, *Forest Resources Assessment 1990: Tropical Countries*, FAO Forestry Paper 112 (Rome: 1993).

Human Development Indices, Selected Mountainous Countries[1] and Regional Averages						
	Gross National Product per Capita	Population Growth Rate, 1980-1992	Life Expectancy, 1992	Infant Mortality, 1992	Adult Literacy, 1990	Urban Population, 1992
	1992$	Percent per Year	Years	Per 100 Live Births	Percent	Percent of Total Population
Bolivia	680	2.5	60	82	77	52[a]
Ecuador	1,070	2.5	67	45	60	58
Guatemala	980	2.9	65	62	55	40
Haiti	370[a]	2.1[a]	55	94[a]	53	29[a]
Honduras	580	3.3	66	49	73	45
Peru	950	2.1	65	52	85	71
Latin America and the Caribbean	2,690	2.0	68	44	85	73
Burundi	210	2.8	48	106	50	6
Ethiopia	110	3.1	49	122	62[b]	13
Madagascar	230	2.9	51	93	80	25
Malawi	210	2.5	64	134	48[d]	12[a]
Rwanda	250	2.9	46	117	50	6
Tanzania	110	3.0	51	92	55[c]	22
Sub-Saharan Africa	530	3.0	52	99	50	29

[1] Includes high plateaus.

Source: World Bank, World Development Report 1994: Infrastructure for Development (New York: Oxford University Press, 1994), and on the following:
[a] From World Bank, World Development Report: Investing in Health (New Yolk: Oxford University Press, 1993);
[b] (for 1980-85) from World Bank, Social Indicators of Development Baltimore: Johns Hopkins University Press, 1994);
[c] (for 1992) from United Nations Development Programme, Human Development Report 1994 (New York: Oxford University Press, 1994);
[d] (for 1987) from United Nations Educational, Scientific, and Cultural Organization, Statistical Yearbook 1994 (Paris: 1994).

1. The two situations: similar yet different

- Both ecosystems are under pressure from their respective human populations.
- Problems and mechanisms involved are simultaneously different and analogous.
- Important highland-lowland interaction in Nepal and the Swiss Alps.
- In Nepal, strong ecological and relatively weak economic interactions. The dominant ecological effects are from the highlands toward the lowlands.
- In the Alps, strong primary economic interactions, leading to secondary ecological repercussions in the highlands. The driving forces emanate from the urban and industrialized centers in the lowlands.

2. Major features of systems dynamics in Nepal

- In Nepal a number of natural resources are threatened.
  - The most important are forests as a source of energy and ecological stabilization.
  - Fertile agricultural land for food and fertilizer production.
  - Forest and pasture fertility for fodder and compost production.
  - Water in the dry season for irrigation and domestic uses.
- Highland-lowland interactions are dominated by the potential effects of growing population in the highlands.
  - The dominating mechanism is the conflict between an increasing number of people at a minimal standard of living and the limited local resources.
  - The quest for food, wood for fuel, fodder, and water must be balanced with the regenerative capacity of the land.
- Negative feedback, such as hunger and impaired health, affect the per capita production and consumption, and population growth.
- The situation is aggravated by socio-cultural, political, economic factors such as land tenure, and government intervention.

3. Major features of systems dynamics in Switzerland

- Pressure on ecological stability derive from economic growth, high levels of production and consumption and technology, rather than population.
- The utilization, and sometimes exploitation, of untouched landscapes as recreational resources threatens mountain agriculture, which is a precondition for mountain ecological stability.
- Highland-lowland interactions are dominated by the activities of people in the lowland urban centers.
- Deteriorating tourism because of impaired environmental quality and overcrowding.
- The essential driving mechanism is the continued growth of productivity, stemming in part from constant societal values in the education system, as well as in scientific and technical research and development.
- Increased industrial productivity, in turn, forces increased agricultural productivity, but lowland agriculture is more of a business, leading to increasing economic disparities between highland and lowland farming, thereby causing greater economic and ecological instability in the highlands.

4. Common factors with different significance in Nepal and Switzerland

- Comparing the two sets of mechanisms just described, one fundamental difference.
- Alpine mountains threatened by economic wealth and technological potency.
- Himalayan mountains threatened by economic poverty and demographic growth.
- Economic-ecological systems dynamics can be portrayed in a function which relates the macro-interrelationships between the human activity system (population, affluence and technology), the quality and productivity of the natural environment, and the economic-ecological import- -export relationships of the system with the rest of the world.
- Ecological stability or instability as determined by the relationship between population, affluence, and the efficiency of technology on the one hand, and the regenerative environmental capacity and import or export of such capacity on the other.

CONSERVATION AND DEVELOPMENT PROJECTS IN MOUNTAIN COMMUNITIES, SELECTED EXAMPLES

Project/Program, and Organization	Location	Activities and Accomplishments
Makalu-Barun Conservation Project, *The Mountain Institute and Nepal's National Parks and Wildlife Conservation Department*	Makalu-Barun Region, Eastern Nepal	In a region of intact forests and high biodiversity, created 83,000 hectare conservation area around Makalu-Barun National Park for the 32,000 residents of seven distinct hill tribes; cre-ated 13 skills training programs and 10 cultural conservation projects; preserved some of Nepal's last riverine tropical forest; established 33 community forest user groups that manage 2,000 hectares of forests, two nurseries that can produce 60,000 seedlings each year, and kerosene depots at the trailhead to Makalu base-camp; project model now being replicated with technical and cultural modifications in Bolivian and Peruvian parks.
Hill Area Development Foundation	Chiang Mai province, Northern Thailand	In heavily deforested watersheds, works with 28 villages of four tribal groups to build terraces, plant and rotate indigenous crop species along contours, form community forests, teach literacy, and help secure land tenure.
Mattole Restoration Council	Mattole River Valley, Northern California	To reverse effects of soil erosion (produced by logging and overgrazing) on salmon and trout, spawning, coalition of 100 community groups has planted thousands or native trees to control erosion; raised and released 250,000 native salmon since 1980 to help restore fisheries.
Bauda-Bahunipati Family Welfare Project, *World Neighbors*	Sindhupal-Chowk District, Eastern Nepal	Project nursery producing 15,000 fodder, fuel, and timber seedlings a year; family planning adopted by 22 percent of fertile couples, and fertility rate reduced from 5.8 to 3.2 children per couple; built 55 new drinking water systems and 525 pit latrines; project now replicated in 38 villages of 153,000 people and run by local NGOs.
Integrated Family and Communal Gardening Project, *AIDESEP'*	Peruvian Amazon	In response to abandoned farms, low productivity cattle pastures, dwindling territories, and assailed cultures, project provides training in organic crop production to 120 communities of 36 indigenous organizations; soil restoration has had 90 percent success rate, reducing toxicity from pesticides by 70 percent; supported 39 model gardens; now studying system for alternative land use model for granting communal land titles.

'Interethnic Association for the Development of the Peruvian Amazon (AIDESEP).
Source: Compiled by Worldwatch Institute from sources cited in endnote 72.

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A Guide To Further Reading

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