Mountains of the world: Mountains, energy and transport

University of Berne, Centre for Development and Environment, Switzerland

2001

tkohler@giub.unibe.ch

Keywords: mountains, resources, energy, transportation, hydroelectric power, Himalayas, Nepal.

Contents

1. Why focus on energy and transport in the mountains?

Over the past decade, the profile of mountains on the global sustainable development agenda has increased, first with Chapter 13 – "Managing Fragile Ecosystems: Sustainable Mountain Development" – of Agenda 21 and more recently by the declaration of the International Year of Mountains in 2002. Energy and transport are key issues in sustainable development, involving vital linkages between mountain regions and adjacent lowlands and urban areas.

Energy from the mountains comes in many forms which have been essential for economic development in adjacent regions: most important have been hydroelectricity and wood. Yet often, mountain people gain little from large energy developments, have received little compensation for the use of their resources, and have been sidelined in national energy policies.

While mountains have long been seen as obstacles to movement, transport networks are essential for providing access to mountain resources and tourism opportunities, and to allow mountain people to get to markets and jobs outside the mountains.

Mountain energy sources

The marked altitudinal gradients of mountains mean that they have huge potential for the production of energy, particularly hydro-electricity, as shown in the map that accompanies this document. Mountain people have long used water energy at small scales, especially for milling. Within the mountains, water energy was the basis for early industrial developments, usually based on local natural resources such as wood and minerals, and has been important in developing textile industries in certain mountain areas. Yet the main energy source for most mountain people remains wood: a resource that is often becoming scarcer, leading to severe environmental and socio-economic impacts. Modern technologies can be used to increase the efficiency of fuelwood use, but their introduction must be sensitive to local conditions, and be properly resourced. This also applies to renewable energies, such as solar and wind power, which have great potential in mountain areas.

Benefits from energy

Energy is essential for life, particularly for cooking, but especially for heating in mountain areas. Local energy sources are also important for artisanal and small-scale industries, which provide employment and income; mountain people worldwide are well-recognised for the quality of their products. Modern technologies based on solar and wind power can provide additional income opportunities, decrease health risks, and provide electricity for lighting and communications. Decentralised production of energy is particularly appropriate in mountains, due to the distance between settlements and the high costs of constructing and maintaining distribution networks. Yet the greatest benefits of energy deriving from mountain areas often accrue to people in the lowland through the export of electricity, wood, and charcoal.

Negative effects of energy use

While wood and other biomass fuels are the principal energy sources for mountain people, inefficient combustion has serious effects on their health – especially for women, the primary users of domestic energy. At a larger scale, pollution from lowland power plants burning fossil fuels often has serious impacts on mountain ecosystems, leading to the weakening and even the death of forests. Where demands for fuelwood are high, harvesting may also lead to severe damage to forests, and the use of manure and other biomass fuels for energy, rather than for fertilising fields and improving soil structure. In some cases, damage to forests may influence slope stability, increasing the likelihood of natural hazards such as landslides and avalanches.

Transport in the mountains

Mountains present major difficulties of communication between the lower areas which surround them. Yet people have always developed trails suitable for people and pack animals through mountains. Since the mid-19th century, road and rail networks into and through mountain areas have expanded for two reasons: economic development and military strategy, which are often linked. High-capacity infrastructure is linked to lower-capacity feeder networks that have improved access for people and the transport of raw materials and goods. More recently, tunnels have removed many of the dangers of travel through mountain areas. Also, new communications technologies are beginning to make the constraints of mountain topography irrelevant.

Benefits of transport networks

Transport infrastructure is essential for all mountain economies: even the most remote village has always relied on traders for salt and other valuable goods. Within the mountains, increasingly sophisticated technologies – bridges, roads, railways, tunnels - have gradually removed the challenges of access. Transport networks make it possible for mountain people to travel to other parts of the own mountain regions and to adjacent lowland areas to study, sell their goods, and look for employment. These networks are also vital for the spread of ideas and innovations and the development of tourism.

Negative effects of transport networks

The construction of even the simplest transport network in a mountain area is expensive. Road and railway construction can have major impacts on slope stability and ecosystems if appropriate methodologies are not used. Once constructed, the infrastructure requires higher levels of maintenance than in lowland areas because of the steep slopes and more frequent natural hazards, such as landslides and avalanches. High traffic levels can lead to severe pollution, with negative effects on the health of both people and forests. For mountain people, the development of transport infrastructure often leads to emigration, especially of younger people, in search of better-paid and more pleasant jobs. Conversely, the introduction of new ideas and attitudes can disrupt mountain cultures.

The development of energy and tourism infrastructures in mountain areas requires that a number of issues related to sustainability are addressed, including:

- how can demands from lowland and urban areas be balanced with the needs and demands of mountain people?
- how can mountain people participate equitably in decisions regarding energy and transport?
- what new technologies can be used to maximise benefits to both mountain people and those in the lowlands?

This report addresses these key questions through documenting local and regional experiences from different parts of the world. It concludes by presenting opportunities for the sustainable development of both energy and transport in mountain regions, with concrete suggestions and recommendations addressed to different stakeholders.

2. MOUNTAINS AND ENERGY

Mountains as global centres for hydropower

Hydropower provides 19% of the world's total electricity supply. Over 150 countries use hydropower and a third rely on it for more than half their electricity needs. While industrialized countries have developed most of their possible hydropower sites, most developing countries have developed little of their potential. The substantial hydropower potential of mountain areas derives from their high gradients, relatively higher precipitation and runoff, and storage of water as snow and ice. Gorges allow the storage of large amounts of water in deep reservoirs behind dams with relatively modest construction, and without inundating a large area. As well as generating electricity, the stored water is often used for irrigation and urban water supply.

Energy for the mountains

Hydropower often provides the most accessible and cheapest option for mechanical power and electricity for mountain communities. Many mountain areas in developing countries have a very long tradition of using vertical axis water mills to turn stone grain-grinders, of which 200,000 are still operational in the Hindu Kush and Himalaya. Here, more sophisticated turbines are being installed to produce electricity from small streams to meet local needs.

For many rural mountain communities around the world, small hydropower stations have provided the first source of power and the basis of electrification. Extending central power grids to scattered mountain communities is an expensive way to provide electricity when demand is low. Where resources exist, isolated hydropower mini-grids are often the best option. The main challenge to their economic viability is to increase the use of power during non-lighting hours. In run-of-river projects (projects without storage structures), electricity can be generated 24 hours a day at no additional cost. Most isolated power plants are, however, only loaded for 4-6 hours a day for evening lighting and television. Promoting organizations encourage electrified communities to use electricity during off-peak hours, with the main goals of reducing unsustainable rates of consumption of firewood and creating non-farm jobs for people within their own communities.

Experience suggests that electricity cannot by itself create new economic sectors but can add value to existing ones; it can create jobs and be used for cooking where certain economic preconditions exist. In Nepal, the best opportunities for electricity-powered productive applications exist in agricultural surplus areas linked to transportation networks and in trekking tourism destinations with a strong local economy. Electric cooking has been most successful in tourist areas where labour to collect firewood is expensive and limited, and where firewood collection is restricted because of national park or conservation regulations such as in the Sagarmatha (Everest) National Park.

Energy for export

Hydropower energy from larger dams and power stations is often exported from mountain areas. While most dams are in the mountains, most of the services they provide - irrigation, flood control, navigation, and electricity - are used by the more densely populated plains and nearby urban areas. Mountain areas in developing countries receive little compensation for providing these services but are subject to negative environmental and social impacts.

In 2000, the World Commission on Dams (WCD) noted that, while the benefits derived from larger dams have been considerable, in too many cases an unacceptable and often unnecessary price has been paid, especially in social and environmental terms. Dam building institutions and agencies have not adequately involved affected people in decisions to build a dam. Neither have they transferred sufficient resources from beneficiaries to affected people. The WCD has put forward a ‘rights and risks’ approach to dam building which proposes that "those groups facing the greatest risk from the development have the greatest stake in the decisions and, therefore, must have a corresponding place at the negotiating table."

Many countries charge developers a royalty for the use of hydropower sites, particularly for larger projects that export energy outside the region. Few developing countries have provisions for sharing this income with affected communities: an important step in compensating them for the use of their resources. Under a 1916 law, communities in Switzerland are entitled to considerable annual payments and quotas of free energy for granting the rights to hydropower development on their territory. Brazil has a 1989 law which requires that, of the royalties paid for using water for power generation purposes, 45% goes to the municipal districts affected by the venture, another 45% goes to the state(s) where the venture is located and only 10% goes to the federal government. Even though money available to municipal districts will not necessarily be spent in the best interests of the affected communities, this is a good start – and other countries are following suit.

Bikash Pandey

Norway has developed over 80% of its hydropower potential. Nepal and Ethiopia have developed less than 1% of theirs.
In China, a third of the counties and 40% of rural townships rely on small hydropower for most of their electricity. In Nepal, 1500 hydropower turbines provide milling services to 2 million people - 10% of the population - and 800 plants of various sizes supply electricity to half a million people not connected to the national grid.

The future of the Icelandic highlands: power plant or national park?

Icelanders are facing their greatest environmental controversy, with heated disputes over plans to dam rivers northeast of Vatnajökull, the country's largest glacier. The government sees this as necessary for the region's economic development. Environmentalists believe these developments will have negative impacts on this area of high conservation value, and offer an alternative vision for its future development through the creation of Europe's largest national park.

Current plans

Iceland's National Power Company plans to build a 650-700 MW hydroelectric power plant - the largest in Iceland, and one of Europe's largest - and sell the energy to a proposed aluminium smelter. Two (EIA) processes, to be concluded by February 2002. The Minister of Environment large glacier rivers would be dammed, and smaller dams constructed in nearby rivers. By law, both the power plant and aluminium smelter must go through an environmental impact assessment has also agreed to establish a working group to evaluate the conservation value of the land north of Vatnajökull, to report at the same time.

The Icelandic highlands

The Icelandic Highlands are unique, characterised by vegetation-free mountains, glaciers, lava, and black sands. As the country's 270,000 inhabitants live close to the coast, the highlands are largely untouched.

Hydropower provides Icelanders with most of their electricity, but only a small fraction of the potential hydropower is used. Existing dams are mostly in southern Iceland, close to the metropolitan area, and in the north. The rivers northeast of Vatnajökull represent about 15% of the unused hydropower.

Economic interests

Iceland's economy is still largely based on fisheries, which provide up to 50% of export revenue. The collapse of the Atlantic herring in late 1960s crystallised the need to diversify the economy by capitalising on Iceland's other major natural resource: renewable energy, from hydropower and geothermal heat. Government policy has been to utilise this energy for large-scale industries, especially aluminium smelters. The government has created an attractive environment for foreign investors, offering favourable prices for electricity.

The hydropower schemes are not only central to government policy for diversifying the economy, but also fit into its rural development policy. Many rural areas, including eastern Iceland, have been experiencing a declining economy and depopulation. Thus, many rural areas press the government to foster economic growth.

Conflicting views

The National Power Company began exploring options for damming the Glacier Rivers northeast of Vatnajökull decades ago. The authorities gave permission to build projects, but these were called off or delayed for various reasons. In 1998, when the government began negotiating with foreign investors about building an aluminium smelter, loud opposition to the project developed.

The original plan was to build a 210 MW power station which would have been exempt from EIA since the operating licence had been granted in 1991, three years before laws about EIA came into force. The project would have meant that a wetland with important habitat would have been submerged. Environmental non-governmental organisations strongly opposed this project, but the exemption of the power plant from the EIA process caused even more controversy. Eventually, the investors decided it would be more profitable to build a larger smelter. This required a larger power station, so the National Power Company had to look for another option and chose to focus on existing plans for a 650-700 MW station. This meant the project, which would almost double Iceland's electricity production, had to undergo a formal EIA process.

The local authorities in eastern Iceland strongly support these plans, but environmentalists continue to lobby against the project, emphasising the area's conservation value, which harbours over 320 plant species and 28 bird species. The parliament has agreed to establish a national park including the whole Vatnajökull glacier, in 2002, but environmentalists argue this should be much larger: 20,000 km2, including the area northeast of the glacier. They point to the increasing importance of tourism, which recently replaced large-scale industries as the second most important source of foreign revenue after the fishing industry. Many tourists come to Iceland because it is one of the few western European countries with large wilderness areas. Thus, the national park could be a better development option since it would strengthen Iceland's image as a natural sanctuary, having a positive impact on the tourist industry.

The end results are far from certain. The final decision will depend on the results of the EIA. Yet it is clear that the lively debate will continue until the matter is settled.

Audur Ingolfsdottir

Different views: potentials of hydropower development in Iceland

Technically possible:	64,000 GWh
Economically feasible:	40,000 GWh
Environmentally acceptable:	studies currently underway
Harnessed (by 1999):	4000 GWh

Source: A. Ingolfsdottir

Hydropower caught in conflicts over water in Central Asia

The Syr Darya River rises in the Tien Shan Mountains and flows to the Aral Sea through the present-day states of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan. The area has a history of 4,000 years of irrigation-based agriculture. In the 1920s, the Soviet government started to centralise the water allocation system, taking it out of the hands of the traditional water masters, elders, and councils. Traditional small-scale irrigation systems were transformed to large systems for cotton production. From the 1940s, the government began to tap an additional potential of the Syr Darya's water:

hydropower. Dams have since been constructed or are under construction on various parts of the river and its main tributary, the Naryn. Today, the challenge of reconciling needs for water in this complex region is immense.

The boundaries of the nations formed after the disintegration of the Soviet Union are based on former Soviet administrative units, not on geographical realities. These boundaries cut apart a large integrated water management system. The rivers now cross national borders several times, and storage reservoirs are located close to national boundaries. This makes the control of water resources on the territory of individual states very difficult, especially because models of water utilisation are contradictory, requiring water supplies for both hydropower and irrigation. Sharing water resources between the states during the process of nation-building is a very delicate political task complicated by deteriorating economies, high rates of unemployment, rapid population growth, and the highly complex ethnic situation.

Upstream-downstream tensions

Although mountains occupy only 38% of the basin of the Syr Darya, they supply 95% of the water that flows down the river. In the natural cycle, water is stored in the mountains during the winter, and released as melt water in the summer, the critical season for irrigation. However, the Naryn-Syr Darya Cascade System, constructed since the 1940s to regulate water flows and generate electricity, has greatly changed this pattern. For Kyrgyzstan, economic imperatives mean that hydropower is generated in winter. At this time of year, the valleys in the downstream parts of the river in Kazakhstan and Uzbekistan are frozen. The solution has been to dump the excess water into a natural basin in the desert, creating the new Arnasai Lake, which has grown to an area of 33,000 km² since 1992. For Uzbekistan and Kazakhstan, where water has traditionally been used in summer for irrigation, this has caused serious problems for agriculture, as well as severe environmental problems, due to the loss of a huge amount of water through evaporation and infiltration, and an increase in groundwater levels. This is one of the causes of the shrinkage of the Aral Sea.

Politics and the lack of reliable data

These problems are well known and are often discussed during meetings between the states. The governments mistrust each other's hydrological measurements; values often vary by 50-100%. The differences can partially be explained by politics, but also result from the economic situation; indeed, the hydro-meteorological survey system is becoming obsolete, as hydrological and meteorological stations cannot be maintained, and salaries for hydro-met personnel cannot be paid. Consequently, there are almost no measurements of water flow at the reservoirs, or of water distribution into the canal systems or rivers. Large international projects are being developed to improve this situation. However, an independent source of information, such as satellite remote sensing, is urgently needed in order to ensure the support of the representatives of all countries involved, and to find common ground to solve the regionally very important economic and political tensions. Once agreement can be reached on quantities of water, further solutions will have to be developed with regard to its allocation.

Elements of integrated regional water management

In the agricultural sector, the efficiency of water use, particularly through the cultivation of water-saving crops, needs to be improved, and locally-adapted conflict management structures developed, using models similar to those that existed before the socialist era. These structures would have to be supported by national laws and regional agreements as well as economic measures, such as differential water tariffs with different prices for agriculture, industry, fishing, domestic use, and hydropower. External and internal costs such as administrative costs, costs for water protection measures, reconstruction and maintenance of dams and canals would have to be covered by an appropriate pricing policy.

Michael F. Baumgartner, Manfred Spreafico, Heinz W. Weiss

Central Asia's water dilemma
Although mountains occupy only 38% of the Syr Darya Basin, they supply 95% of the water that flows down the river. This water is crucial for hydropower generation, domestic supply, and irrigation in this mostly dry region. The countries that share the Basin face a major political challenge: how can they achieve equitable distribution of water among themselves?

Developing small-scale hydropower in Nepal

Mountain people are often disadvantaged by being cut off from transportation and communication. Yet there is often great potential for the development of decentralised hydropower to stimulate sustainable local development. In Nepal, 80% of the population lives in rural areas, adding an important political dimension to decentralised electrification. Nepal's installed electric generating capacity is around 390 megawatts (MW), of which about 85% is hydroelectric and the remainder diesel power. There are frequent power outages, and only 15% of the population has access to electricity. Only 1% of the hydroelectric potential, estimated at 83,000 MW, is currently exploited. Potentially, Nepal could supply both its rural and urban needs and even be a large power producer and exporter to neighbouring countries.

The economics of rural electrification

Least-cost power generation schemes, streamlined for production economics, are often very large. Their production is geared to earning foreign exchange in distant industrial centres and neighbouring countries. Rural electrification is, if at all, of marginal concern. If profits are the main consideration, economies of scale never favour small schemes. Scaling down hydropower units from 10 to 1 MW increases specific costs of installed capacity by 40% and scaling down from 1 MW to 100 kW by another 70%. However, for remote areas far from the national grid, isolated power utilities have a competitive edge. Harnessing water power is by far the best choice, leaving photovoltaic schemes - with five times higher production prices at present levels – far behind.

The Salleri Chialsa small hydro project

Salleri is the district headquarters of Solukhumbu, 80 km south of Mount Everest. By foot, the nearest road head is three days distant, over high mountain passes, and the nearest airfield is an hour away. Fourteen years ago, the first electric bulbs were switched on, fed by a 400 Kilowatt (kW) small hydro plant on a small mountain stream below Salleri. Today, the Salleri Chialsa Electricity Company Ltd. (SCECO) is fully autonomous. The power utility operates two cross flow turbines and an isolated grid, providing electricity to 900 commercial and domestic consumers. With 98% grid availability, reliability is second to none. Small business and cottage industries now provide quality employment opportunities and income to a well-educated new middle class.

The Salleri Chialsa Project was initially supported by a Swiss government agency, which commissioned the design and construction of the plant and grid. An extensive training component was included with the technical assistance package, ensuring know-how transfer in all relevant technical, organisational, and financial aspects. Long before the current trend of privatisation of infrastructure utilities, SCECO was designed as a private shareholder company, including local consumers as shareholders. Its financial condition is sound and stable, with a remarkable sum set aside for depreciation. Coming challenges are to develop and manage local telecom and television systems. SCECO envisages the construction of a second small hydro plant, to meet rising demands in the service area.

Distributing the benefits of hydropower

In coming decades, Nepal's power sector is expected to boom tremendously. Hydropower projects currently under construction, planned, and proposed should boost the country's total generating capacity by a factor of 65, to 22,000 MW, half of the country's economic hydropower potential. The government's tax and duty concessions plus a commitment to purchase generated power strongly encourage private investment in the hydropower sector. Losers in this rapid development will be the country's remote areas served by decentralised small hydro schemes, as independent power producers will mainly direct their investments to large, least-cost schemes, connected to the national grid's high tension backbone. While small hydropower schemes (less than 10 MW rated capacity) currently account for 9% of Nepal's hydropower capacity, only 0.1% of upcoming capacity will be generated in small hydro schemes. However, as the Salleri Chialsa example shows, electricity can trigger a modest, but sustainable development in remote areas, benefiting a large portion of the population. Yet without initial external support, the scheme would never have taken off. Such support from concerned governments and donors is crucial to ensure well-balanced decentralised development.

Walter Zimmermann

Solar energy in the Himalaya and Hindu Kush

The abundance of solar energy in the Himalaya and Hindu Kush has prompted many solar energy programmes. However, they have not yet resulted in any significant use of solar energy, mainly due to the lack of affordable technical solutions and adequate institutional mechanisms to ensure energy resources are matched with needs, the inadequate appreciation of socio-economic and cultural factors, and the failure to fully understand the spatial characteristics of the mountains. Nor has the allocation of financial resources for developing solar energy in the mountains received priority on national agendas.

The potential of solar energy

Regions with dry climates within 35° of the equator are particularly suitable for the utilisation of solar energy, since there is more diffuse radiation than at higher latitudes, and less cloud cover. In addition, snow peaks act as large reflectors to raise the albedo, locally increasing the amount of radiation. Relief, altitude, slope, and aspect significantly influence the availability of solar energy in mountain areas and thus require careful understanding.

Across the region, there is a large difference in solar radiation in December and January, due to prolonged foggy mornings in some valleys. Variation in summer (June – August) is due to difference in cloud cover. Radiation is higher in places such as Lhasa and Chitral because of low rainfall, and low in places like Lumle in Nepal which experiences heavy rainfall during the monsoon season. The lowest variation across the region is in April, when the sky is clearest.

The overall amount of energy required in mountains is generally quite low due to the scattered settlement pattern and lack of infrastructure development. Energy potential in the mountains is also extremely scale-sensitive. Thus, decentralised renewable energy systems based on solar, water, and wind energy are particularly appropriate. Small-scale interventions in mountain communities also entail fewer risks compared to large-scale interventions.

There are many options for the use of solar energy. Solar cookers are widely used in the mountain areas of China and India, and there have been initiatives to promote them in Nepal and Pakistan. Space heating, using passive solar building technologies, has been incorporated in the retrofitting of buildings in Tibet and in Ladakh in India. Lighting with solar home systems and lanterns has been successful in many areas, but centralised systems failed in Nepal and Pakistan. Solar power also has great potential for telecommunications, television, radio, and computer operation; almost all remote airport and telecommunication facilities in Nepal are powered by solar energy. However, there is still a huge potential for the use of solar energy in the region.

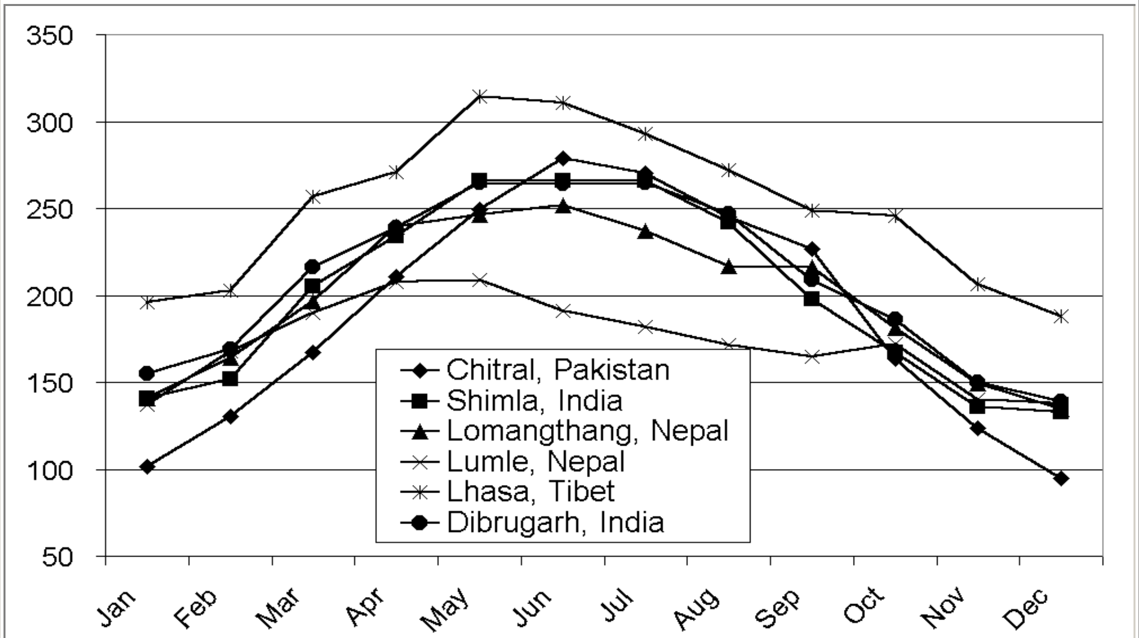
Facilitating the adoption of solar photovoltaic (SPV) systems

The attractions of photovoltaic arrays include the lack of moving parts, very slow degradation of properly sealed cells, possibility for modular systems of various sizes, and extreme simplicity in use. While SPV systems still cost five times more than conventional sources of energy production, they can have a 'niche' market for isolated and remote mountain areas with no feasible options for lighting, communications, or computers. Such facilities not only improve the quality of life of mountain people but also provide opportunities for them to diversify income-generating activities, to reduce health hazards and, for children, to study more.

Various key factors must be considered when formulating policies and actions for the adoption of SPV systems. Subsidies and incentives should primarily be based on economic and social equity analysis; often, most owners of solar home systems belong to high-income groups. Properly designed subsidy programmes along with full-cost recovery-based financial operation of SPV programmes are minimum prerequisites for financial sustainability. In this context, access to financial resources must be transparent and flexible enough to facilitate access by poor and marginalised people. Women should actively participate in designing and implementing SPV programmes, as they are the primary users; promotional activities have generally not recognised the socio-cultural implications of technology adaptation. Commercialisation also has to be developed, with governments creating the right kind of policy atmosphere to attract investments from entrepreneurs, and facilitating effective schemes for standards, warranties, and insurance.

A key need is coordination between various donor agencies and government institutions, to avoid duplication of effort. Donors may be interested in capacity building, marketing technologies, research and development, or promoting SPV technologies in specific areas or to specific ethnic groups. Each should be allowed to function with clear mandates and objectives. The lessons learned and successful strategies in disseminating SPV systems must be taken into consideration while designing future programmes.

Kamal Rijal



Monthly averages of daily global solar radiation in specific areas of the Hindu Kush and Himalaya. Regional variations are highest in the monsoon season (May – September), when regions in the rain shadow (Lhasa, Tibet) have much higher radiation due to low cloud cover, than lowland areas which are fully exposed to the monsoon rains (Lumle, Nepal). (Source: ICIMOD, K. Rijal)

Wind power in the mountains: examples from Switzerland and Norway

Worldwide, nearly 14,000 wind power installations produce 20,000 GWh. Growing at more than 30% a year, wind energy production is becoming a serious element of the electricity market and may be regarded as a prime example for sustainable development. With recent price increases for oil and gas, wind power is now the cheapest source of electricity in the USA. Globally, development is moving away from coasts, either to large offshore wind parks in the sea, or to inland locations including mountain regions.

Wind power in the mountains

Mountain regions have many specific climatic conditions. Valley winds starting from south slopes (north slopes in the southern hemisphere) are characteristic. When the valley bottom slopes, the wind may blow as a canyon wind either up or down the valley. Winds blowing down the lee side of mountains can be very strong. Examples are the *foehn* in the European Alps, the *chinook* in the Rocky Mountains, and the *zonda* in the Andes. Wind velocities over mountain ridges or crests are higher than in surrounding areas. However, the steeper the slope and the rougher the surface, the stronger is the turbulence which may remove the advantage of higher wind velocities.

The Swiss wind energy context

Wind power could produce 3.5% of Switzerland's electricity consumption. However, the development of the wind energy market has been slower than in neighbouring countries. Existing projects show that, in very good locations with modern converters, capacities of up to 2000 full load hours are possible. The production costs of the resulting electricity are less than 20 c/kWh (less than ca. 0.15 US$/kWh). Wind power also provides highly welcome winter electricity from a renewable source, at times of peak demand.

However, many high-potential areas in mountains and other cold regions are heavily affected by rime and ice. At an altitude of about 2,000 m, icing conditions must be expected on 10 to 30 days per year, substantially reducing the production capacity of a wind power plant. Wind power exploitation in mountain areas is further restricted by difficult grid connections and access.

Wind power installations also have impacts on landscape quality. Given Switzerland's intricate landscape, no large wind parks are conceivable. Regional coordination and the active inclusion of landscape protection and conservation groups are helpful in finding broadly accepted solutions when constructing wind power installations.

The wind energy industry

Europe's highest wind power installation is operated on top of the Titlis**,** at 3000 m. Due to technical hitches, icing, and very strong turbulent winds, the energy production of this 30 kW installation remains less than expected. An 850 kW wind power installation on the Gütsch (2400 m) above Andermatt in the Central Alps is planned for 2001. Experience regarding the construction and operation of this large wind turbine will be valuable for further projects in the mountains, particularly to supply energy for snow cannons in tourist areas, where the landscape has already been heavily impacted by tourism infrastructure.

While there is currently no wind power industry as such in Switzerland, Swiss firms increasingly produce components for wind power installations, small wind installations, and engineering tools, such as modelling software for complex terrain. Given the limited access possibilities and the severe climate experienced by both offshore and mountain installations, which mean they must be very reliable, there are also market opportunities for the expensive but high-quality Swiss electrical and gauge industry. A substantial domestic market will increase the sales potential for all these products and is a prerequisite for successful further developments.

Wind power: an option for mountain farmers?

Wind power installations have great potential at windy locations in mountain farming areas. Production for hamlets or Alpine cooperatives – "green energy for green products" – is possible, as is the sale of electric energy to others, such as ‘green’ energy suppliers. Wind power installations can be attractive excursion destinations; guided tours and direct sales of agricultural products can bring additional return to energy production and sale.

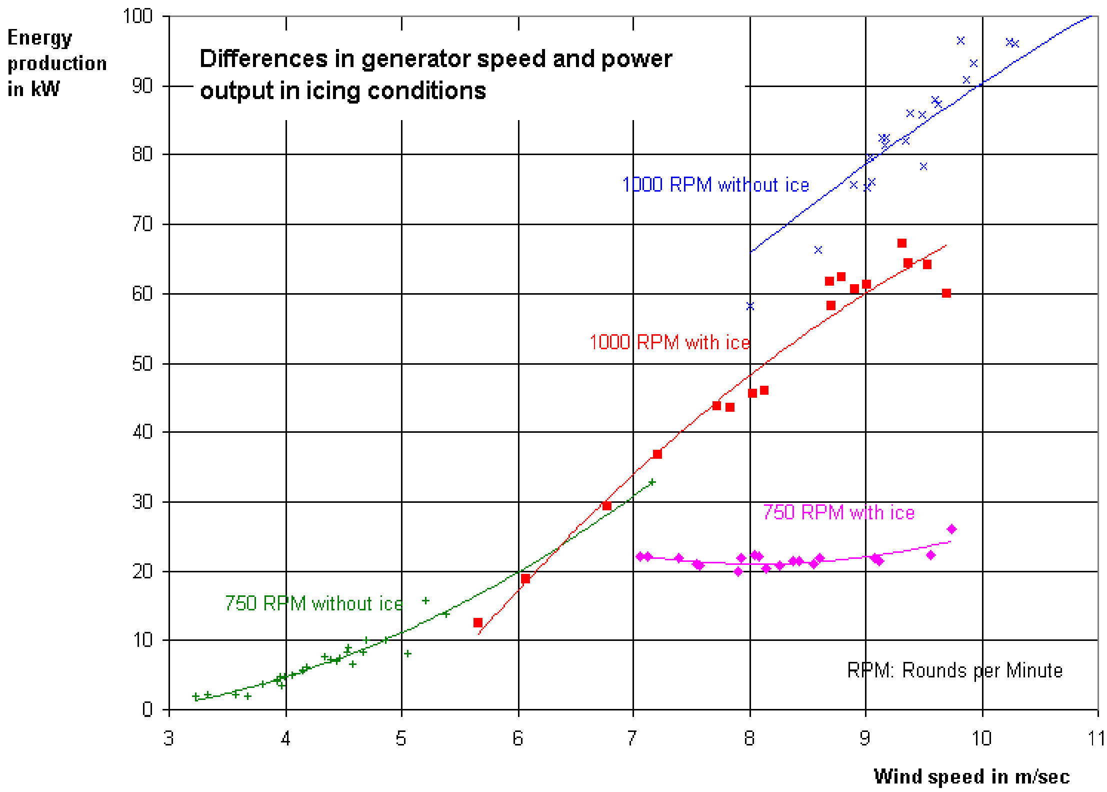
Energy policy

The future growth of the wind energy market - and with it a sustainable and economically meaningful production of energy - will depend strongly in Switzerland, as in other countries, on political consent for the development of renewable energies.

Debate in Parliament on the electricity market bill has led to very positive tendencies, such as a legal requirement to declare the source of electricity, direct access for renewable energy, a single network company for high-voltage transmission, and refunding by this company of back-supplied current. After this legislation comes into effect, there will be good basic conditions for developing wind power in Switzerland.

Robert Horbaty, Rudolf Rechsteiner

Wind power in Norway
Norwegian utility Nord-Trøndelags Elverk is planning a 15 MW wind farm of ten turbines in **Vikna**, north of Trondheim. Officials have apparently been pleased with the output and operation of the existing 2.2 MW wind farm of turbines at the site on top of a steep coastal mountain. The availability has been 95% and the plant has produced more energy than expected in the rainy area. A specially developed lightning protection system has reportedly helped the turbines survive several strikes.



Power curve of a 150kW-wind turbine at 1300 m in the Jura mountains of Switzerland. Icing reduces the speed (RPM of the rotor blades even in high winds, which leads to a significant reduction in energy production compared to lowland areas. (R. Horbaty)

Sustainable fuelwood use in mountain areas

At a global scale, fuelwood remains the main source of energy for cooking and heating in mountain households. In many mountain areas, especially in developing countries, there are no readily available energy substitutes. While energy-saving devices are being developed, mountain people can often not afford them. Sustainable fuelwood energy development needs to take a long-term perspective. This must not only be based on supply and demand and the dissemination of appropriate technologies, but also consider the local socio-economic situation, including property rights and access to resources and technologies.

Current trends in the Himalaya

In mountain areas, demands for space heating are greater than for cooking. For example, in the mountains of Nepal, 32% of the energy required by households is used for cooking and 56% for heating, compared with 40% for cooking and 36% for heating in the lower hill areas. The cooking, heating, and process heat requirements of small cottage industries are also fulfilled by fuelwood. The heavy dependence on fuelwood is further worsened by the low level of efficiency of utilisation of these fuels - typically below 20%; and by the creation of health hazards, particularly for women who are the managers, producers, and users of energy at the household level.

Across the Himalaya, the demand for fuelwood exceeds the sustainable supply, and thus the process of destruction at the margin is common over much of the region. As the availability of fuelwood decreases, more time is required for its collection. Continuous unsustainable use of fuelwood forces rural people to use other biomass fuels, further degrading the environment. Those with higher incomes often decide to switch to kerosene, electricity, or gas. However, if these are not available or if the supply is not reliable – a common phenomenon in mountain areas - they may decide not to upgrade their fuel. Likewise, where fuelwood is scarce, people may downgrade to lower quality fuels. Fuelwood is currently collected in the slack season, when there are fewer demands on people's time, at no cost other than the time and labour involved. Given widespread unemployment, the opportunity cost of time for unskilled people is lower than the price of fuelwood, thus it will continue to dominate the mountain energy scene in the foreseeable future.

Approaches towards sustainability

Most governments and donor agencies have perceived fuelwood in terms of an energy demand and supply problem. This has led to recommendations to plant more trees, reduce consumption through introducing improved technologies, and upgrade the quality of biomass fuels. Modern cooking and heating stoves, biomass briquettes, and gasifiers fired by fuelwood can be used for meeting different end uses such as motive power, cooking, heating, and lighting. However, these interventions have often failed due to inadequate evaluation of the diverse traditional technologies and lack of regard for the socio-cultural values of mountain people, particularly women.

Biomass fuel production and use are intimately integrated into broader processes of resource management in local production systems. Fuelwood problems emerge gradually, as people respond to a variety of resource stresses. This means that fuelwood stress rarely manifests itself as a simple shortage of fuel. It reflects the failure of local and national governments to establish the conditions that would allow efficient and sustainable allocation of land and resources between woods and cropland, food and wood production. Issues related to the distribution of control over decisions concerning land and other resources lie at the heart of effective fuelwood policies and programmes for mountain areas.

Activities to be undertaken in a fuelwood-led energy approach will vary according to local conditions. However, a series of general policy interventions can be defined. Property rights, especially for the groups experiencing the worst problems over access to fuelwood resources, must be secured. Market functions must be improved by eliminating policy-induced distortions in the prices of different types of energy resources and technologies. Access to and management of various renewable energy technologies and commercial fuels needs to be improved so that mountain people have the options to make appropriate decisions. Many technological options, which are not affordable in the present context, may become affordable if properly integrated with community, social, and agro-forestry schemes, and income-generating activities. Planning institutions generally need to be strengthened, and coordination between agencies – and also with the private sector – needs to be improved, reflecting the cross-sectoral nature of fuelwood issues. Finally, local people should be directly involved, through effective institutional structures that give them real control over the decisions that affect their lives.

Kamal Rijal and Binayak Bhadra

At a global scale, fuelwood remains the main source of energy for cooking and heating in mountain households.
In mountain areas, the demand for space heating is greater than for cooking. In the mountains of Nepal, 32% of the energy required by households is used for cooking and 56% for heating, compared with 40% for cooking and 36% for heating in the lower hill areas.

Sectors	Traditional energy devices	New options available
Cooking	Traditional stoves (3-10%) Charcoal kiln (3-10%)	Mud-built improved cooking stoves (15-20%) Briquetting technology and stoves (50%) Efficient charcoal kiln (25-30%)
Heating	Tripod stands (3-5%) Charcoal kiln (3-10%)	Metal stoves with different designs (25%) Briquetting technology and stoves (50%)

		Efficient charcoal kiln (25-30%)
Lighting	Wooden stick of chir pine (n.a.)	
Process Heat	Traditional fuelwood Kiln (10-15%)	Efficient fuelwood kiln (25-30%) Briquetting technology and end-use device (50%) Efficient charcoal kiln (25-30%) Biomass gasifiers (40%)
Motive Power		Biomass gasifiers (40%)

Figures in brackets: efficiency of energy conversion in percent.

Fuelwood-based traditional energy devices and new technologies employed in mountain areas. The new options increase energy efficiency considerably; this in turn can reduce the workload of women who collect firewood and relieve pressure on scarce wood resources. (Source: ICIMOD and CRT, K. Rijal)

Mountain architecture: ways of making best use of energy

(In preparation)

The cultural and spiritual dimensions of mountain energy

As the highest and most impressive features of the landscape, mountains evoke a profound sense of wonder and awe. Storms thundering about their peaks, the dramatic play of light on their summits, their towering heights and plunging chasms - all create impressions of overwhelming power and grandeur. People around the world have long regarded the awe-inspiring power of mountains as a manifestation of spiritual energy and meaning.

The ancient Chinese believed the mountains to be so charged with spiritually transformative powers that their term for embarking on religion means "to enter the mountains." Moses was called to the top of Mount Sinai, wrapped in cloud and thunder, to face God and receive the Ten Commandments and the Torah. Native Americans climb hills and peaks on vision quests to expose themselves to spirit beings who could guide them. Many hikers and climbers now go to mountains in search of spiritual inspiration and renewal.

Mountain deities

For many cultures and traditions, the spiritual energy of mountains comes from, or takes the form of, deities who reside on or within mountains. Hindus regard Mount Kailas in Tibet, for example, as the abode of Shiva, one form of the supreme deity. Others, including communities in South America and New Zealand, revere the mountains themselves as their ancestors. For Western monotheistic traditions, mountains can be places of worship where one can communicate with the supreme deity.

The source of the spiritual energy of mountains can also be impersonal or natural. Chinese landscape paintings seek to awaken a sense of the Tao, the spiritual essence of nature that can be glimpsed like a mountain peak materializing out of the mist. For Western artists and poets, the uplifting physical characteristics of mountains awaken a sense of the infinite and the sublime. Jean-Jacques Rousseau wrote, "In effect, it is a general impression experienced by all men, even though they do not all observe it, that on high mountains, where the air is pure and subtle, one feels greater ease in breathing, more lightness in the body, greater serenity in the spirit."

Blessings from the mountains

The spiritual energy of mountains can be a source of blessings: peaks such as Mount Kenya, Popocatépetl in Mexico, and the San Francisco Peaks in Arizona are revered as generators of rain clouds, places of springs, and headwaters of rivers on which numerous societies depend. As sources of life, mountains may provide the blessing of fertility; for example, many elderly women climb China's Tai Shan to make offerings to have grandchildren.

Mountains are also viewed as major sources of healing. Female shamans in Japan and Korea routinely climb sacred mountains to charge themselves and conduct healing rituals for their patients. Andean curanderos or traditional healers draw their powers and guidance from their relationship to sacred peaks. The extreme climates and diverse ecosystems of mountains make them major sources of medicinal herbs throughout the world. In Europe, many sanatoriums have been located in mountains, based on the perception that the mountain air and environment have special curative properties.

Much of the modern appreciation of mountains derives from the perception of them as sources of spiritual and physical well-being, as recognized by John Muir to help start the environmental movement in the United States: "Climb the mountains and get their good tidings. Nature's peace will flow into you as sunshine flows into trees. The winds will blow their own freshness into you, and the storms their energy, while cares will drop off like autumn leaves."

Harnessing spiritual energy for development and conservation

The spiritual energy of mountains attracts millions of pilgrims and tourists throughout the world, bringing money to local economies, but also leading to adverse effects on the environment and the sacred and cultural value of the sites. Many more pilgrims than trekkers visit the Himalaya, and heavily frequented mountain shrines are severely degraded, with deforestation, litter, sewerage, overcrowding, and other problems. Mass tourism with noisy buses has made contemplation nearly impossible at the Greek monasteries of Meteora, and most of the monks have left for Mount Athos. Such an impact will eventually destroy much of what makes a mountain site or pilgrimage attractive to tourists.

Tourism and other kinds of development should respect what makes a particular place spiritually or culturally significant. If, for example, a mountain is viewed as a sacred center off-limits to climbing, visitors could be encouraged to circumambulate rather than climb it. If the presence of tourists interferes with traditional religious practices or the special quality of the experience, restrictions may need to be placed on the number of visitors and where they can go. Any truly sustainable development of a mountain site should maintain the spirit of the place in the eyes of those who see it as a source of spiritual energy and meaning.

Edwin Bernbaum

Pilgrims help restore a mountain landscape

The motivation for pilgrimage can be a powerful force for protecting the environment and improving local conditions. An innovative program at Badrinath has Indian scientists and priests working together to inspire pilgrims and others to replant trees for reasons that come out of their own religious and cultural traditions. They draw, in particular, on the idea that people can enhance their pilgrimage experience and obtain additional blessings by helping to restore an ancient forest sacred to the deities whom they have come to worship.

The ancient Chinese believed the mountains to be so charged with spiritually transformative powers that their term for embarking on religion means "to enter the mountains."

Human energy in the mountains

The livelihoods of many millions of people living at high altitudes depend not only on wood, animal power, fossil fuels, and renewable energy sources, but also on people's own physical effort expended in subsistence activities such as agriculture and pastoralism, or for payment, particularly in mining and tourism. At the same time, new means of transport, increasing transit across mountains, and the growth of tourism and mountaineering, mean that the number of people visiting mountains – including high altitudes – is increasing rapidly.

Consequently, it is important to understand the constraints to travel and work at high altitudes.

Three quarters of the energy released in the human body is in the form of heat, leaving only one quarter for the work of respiration, circulation, and other organic functions, as well as for physical and mental exertion. A resting adult at sea level burns 60-100 calories of fuel (food or body tissue) per hour: an average of 2000 calories per day. At 2500 m, this figure increases to over 2200 calories per day, and at 4000 - 5000 m to over 2500 calories per day. At all altitudes, hard work requires three times as much as these average figures indicate. The amount of oxygen required to release this energy varies depending on the individual and on metabolic factors. When the available oxygen supply does not meet demand, the body falters and may fail.

High energy requirements for mountain work

Energy is particularly necessary in mountain environments not only for organ function and work but mostly to produce and conserve body heat in the intense cold and wind chill. While other species have different protections against cold such as fur, thicker hair, or feathers, humans rely on shelter and special clothing. However, our ability to do physical work decreases by 3% for every 300 m of altitude gained; the rate of decrease is slightly larger at much higher altitudes. For sea-level people going to a high altitude, work capacity improves only very slightly over time as they adjust to the lack of oxygen in the process of acclimatisation. Breathing and heart rates rise, and new red blood cells and hemoglobin are produced to increase the oxygen-carrying capacity of the blood. Yet, at high altitudes, even well-acclimatised lowlanders have a lower work capacity than those coming from these altitudes. Long experience shows, for example, that miners coming from low altitudes can acclimatise, but the stress of working at high altitude limits productivity and can be a long-term health hazard.

Acclimatisation and adaptation

People ascending from low to high elevations are subject to a variety of altitude-related illnesses if they go too high too fast. Most people are unaffected at 2000 m, but almost everyone has symptoms of mountain sicknesses if they go rapidly above 4,000 m. However, most individuals who ascend slowly to moderate elevation acclimatise, some more slowly than others. Conversely, people who live for generations at higher altitudes show genetic adaptation, reflected in characteristics such as greater lung capacity, lower blood pressure, and blood which is more effective at diffusing oxygen into the tissues. Mountain sicknesses affect thousands of tourists who go up too rapidly to even moderate elevations (2500 m - 3500 m). Every year, they result in coma and death for a number of visitors. Some, but not enough, improvement has been achieved by more widespread information about the risks of going too high too fast.

Humans function best near sea level and, as they go higher, face many problems. Mountains of even modest elevation can be dangerous to unprotected and uninformed visitors. The combined effect of lack of oxygen and exposure to wind is important even on low mountains and becomes a formidable danger on high ones. Lack of oxygen and freezing temperatures, storms, avalanches, and rockfall make very high mountains extremely hazardous. Even those well trained and protected are unable to do as much mental or physical work as they can at lower elevations.

Charles S. Houston

On average, our ability to do physical work decreases by 3% for every 300 m of altitude gained.
Common altitude illnesses A common altitude illness is Acute Mountain Sickness, characterised by headaches, nausea, weakness and other symptoms. It is more unpleasant than serious and usually disappears in about 48 hours. By contrast, High Altitude Cerebral Edema is dangerous; it manifests itself in changes in mental activity, judgement, energy, and muscular coordination, progressing to coma and death if not treated. High Altitude Pulmonary Edema causes shortness of breath and coughing of blood, and may lead rapidly to coma and death.
The hazard of high altitude combined with wind Air temperature perceived by humans is strongly affected by wind. A temperature of –6ºC in a light breeze of 25 km/h feels like –20ºC in calm air.

3. MOUNTAINS AND TRANSPORT

Dilemmas of transport and energy development in Peru's Cordillera Carabaya

Roads built through remote mountain ranges represent development opportunities but may also lead to rapid, and often destructive, social and environmental changes. Roads permit economic development, but this must be carefully tailored to local conditions to minimize unintended consequences and degradation. A balance in project design that safeguards the interests of local inhabitants and ensures environmental preservation - even if this requires some lowering of economic objectives - may lead to long-term economic benefits that far exceed those of shortsighted, hastily implemented projects.

In southern Peru's Cordillera Carabaya, glaciers loom directly above tropical rainforests. The region is typical of the ecologically important yet economically undeveloped regions along the steep Amazonian slope of the central Andes. Its topographic complexity and remoteness long kept it off national and international agendas. Now, its considerable economic potential in terms of resource exploitation, tourism, and hydroelectric generation has been receiving increased attention. Road building, the key to ending isolation, is challenging and expensive.

Roads: The Transoceanic Highway

The key to current development initiatives is the Transoceanic Highway, which aims to link Pacific Basin markets with the Amazon Basin and Brazil. Begun as a local-scale response to stressed social conditions in the 1950s in highland Peru, the road has grown in scope and importance, and its completion is now a development objective serving both national and international agendas. Its impacts may be economically beneficial to Peru in the short-term through increased trade and resource extraction, but longer-term benefits are questionable, especially with regard to the environment and regional populations. In particular, the highway enters the Amazon rainforest at the foot of the Carabaya between two existing nature sanctuaries: Manu National Park, a World Heritage site; and Tambopata-Candamo Reserve, which may host the greatest biodiversity on Earth. Hundreds of square kilometers of this rainforest have been degraded near the road at Hueypetue, where a gold rush has been ongoing since the early 1990s. Existing roads have fueled this boom by allowing the import of over 1000 pieces of heavy earth-moving machinery and daily convoys of fuel trucks to support the mining, and facilitating immigration of workers. The highway's completion will lead to further extraction of gold and timber, and the conversion of rainforest to agricultural land as pristine forests become more accessible.

Tourism: a passing opportunity?

The most sustainable and potentially greatest economic benefit to Peru of the Transoceanic Highway could come from managed development of a tourist industry facilitated by improved access to a region rich in culture and tradition. Neither local nor national governments have yet exploited this alternative, though tens of thousands of tourists pass nearby each year while visiting the Cusco and Lake Titicaca regions. A sustainable tourist industry in the Carabaya would hopefully also diminish the drive for more destructive activities.

Hydropower: The San Gaban scheme

The building of roads into the Carabaya has allowed some of the region's considerable hydroelectric potential to be realized. The foothills are one of the wettest zones on Earth, and glaciers in adjacent highlands ensure sustained river flows in dry seasons. The San Gaban II plant, the first of four units of a major hydropower initiative, became operational in 2000, significantly increasing the electrical supply for urban areas and industry in southern Peru. The US$208 million cost of this 110-MW facility, built by a consortium of Peruvian, Brazilian and French concerns, came primarily from Japan's Eximbank. Made possible by the Transoceanic Highway, the San Gaban scheme is playing a significant role in accelerating road construction to bring in heavy engineering equipment.

Yet there are flaws in this development success. San Gaban II offers impetus for development and modernization across the region, but has yet to provide electricity promised to most of the Carabaya's rural people. It bypasses local inhabitants for greater national interests - including two multinational mines, allocated 32% of the electricity generated. Also, the valley is prone to natural hazards: earthquakes, floods, landslides and debris-flow avalanches. A major hydropower plant further north along the Andes, at Machu Picchu, was destroyed in 1998 by an avalanche caused by glacial melting associated with an El Niño event. The input from San Gaban II has eased the precarious state of electrical supply in southern Peru since this setback, yet the possibility that a similar disaster could befall the San Gaban scheme must be appreciated and contingencies provided.

Anton Seimon

The challenges of Alpine transit traffic

Straddling 8 countries, the Alps are home to over 11 million people and a recreational area of European importance, but they are also a major natural barrier to continental passenger and goods traffic. For centuries, people crossed the Alps on foot and with pack animals. The need to increase the capacity of transit routes became obvious at the beginning of the Industrial Revolution. The construction of the railway transit routes in the late 19th century opened the age of mass traffic. In the 20th century, railway construction was limited to increasing the capacity of the existing routes while road infrastructure was greatly expanded due to the popularity of the automobile. Today, 20 transit routes for passenger and goods traffic cross the Alps. Nine of these are of international importance.

Trends in rail and road transit

Passenger and goods traffic on the Alpine transit routes grew vastly during the last two centuries. Over the same period, the relative proportion of the total traffic by rail and road changed dramatically: except for goods transport through Switzerland, Alpine transit traffic mainly uses roads. Trends in transit traffic are the precondition as well as the consequence of economic and political trends in Europe, such as growth, opening up of markets, European integration, regional specialisation, and just-in-time production.

The central dilemma: dispersion of benefits, concentration of costs

The effects of Alpine transit traffic are manifold, ambivalent and varied. In the Alpine area, the positive effects come from increased accessibility: centres outside the Alps are accessible to Alpine inhabitants, and the Alps are accessible to tourists. Positive effects on employment are both direct, e.g., the maintenance of traffic routes and traffic services, and indirect: for example, tourism, catering, and sports. The negative effects are associated with constructing and operating transportation infrastructure in difficult terrain as well as with the high volume of traffic. These include the high costs of construction, maintenance and operation; the large areas required for communication systems; fragmentation of natural habitats and their damage by pollutants and natural disasters; interference with sensitive landscapes; pollutants, noise, and vibration; catastrophes relating to transport of hazardous materials and accidents in tunnels; and decreased quality of life for people, fauna, and flora.

Outside the Alps, economic growth due to expanded markets for raw materials, agricultural and industrial products, and tourism is a positive effect. Negative effects are more indirect. For example, trans-Alpine traffic encroaches upon transport networks and living space in neighbouring areas.

The central dilemma of trans-Alpine traffic is the contradiction between the continental dispersion of the benefits and the local concentration of costs. While the benefits are spread over a wide area including centres of economic development outside the mountain area, the costs of infrastructure and operation as well as the negative impacts on human lives and the environment accrue almost only within the Alps.

Challenges and policies for Alpine transit traffic

Recognising the forecast trends in transport demand and the objectives of sustainable development and the Alpine Convention, the eight Alpine countries and the European Union (EU) have committed themselves to discouraging further growth of Alpine transit traffic on roads, by shifting as much cargo as possible from road to rail. No new transit roads will be built. The railway structure will be further extended and customer- and environmentally-friendly public transport systems promoted instead.

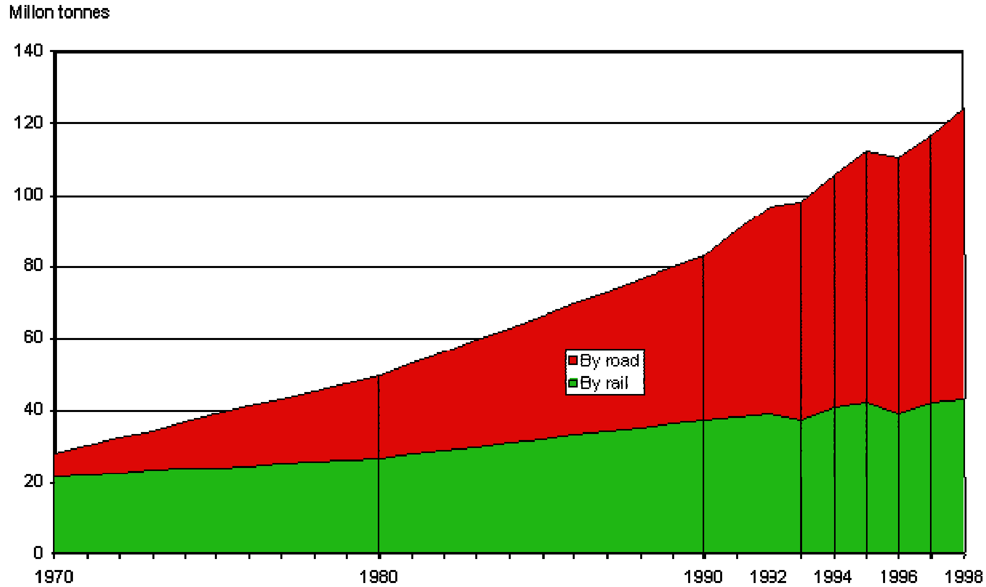
Switzerland, which together with Austria bears the brunt of trans-Alpine traffic, aligned its transport policy in this direction some time ago and secured this position in an agreement with the EU. The main aim is to shift goods traffic from road to rail. The number of truck trips across the Alps - 1.3 million in 1999 - will be halved to 650,000 per year by 2009 at the latest. Five supply and demand measures will be used. First, building a New Rail Link through the Alps to promote combination transport, by enlarging railway tunnel sections for pick-a-back transport and building and operating terminals, some in neighbouring countries. Second, increasing the general truck weight limit from 28 to 34 tons (from 2001), and then to 40 tons (from 2005), with limited quotas for 40-tonne trucks (from 2001). Third, introducing power- and emission-related taxes for trucks over 3.5 tons (from 2001). Fourth, prohibiting trucks over 3.5 tons at night and on non-work days. Finally, stopping further development of road capacities.

It is yet to be seen whether these measures will achieve the desired effect. In any case, the problems of Alpine transit cannot be solved by the Alpine countries alone; a comprehensive and coordinated European transport policy is needed.

Peter Keller, Christian Heimgartner

New Rail Link through the Alps (NRLA): the example of Switzerland	
Aim:	Increase railway transport capacity and quality through the Alps, with the main objective of shifting transalpine goods transport from road to rail
Measures:	Construction of two transit rail routes
Core elements:	Construction of two new base tunnels: Lötschberg (35 km), and Gotthard (57 km), and upgrading of the main feeder lines
Period of construction:	1999-2016 (including main feeder lines)
Costs:	US$ 8.5 billion
Financing:	Secured by special funds (heavy vehicle tax (LSVA), mineral oil tax, value-added tax (1‰), and debt (max. 25%))
Political context:	Transit Agreement between Switzerland and the EU (1992); Bilateral Land Transport Agreement between Switzerland and the EU (1998)

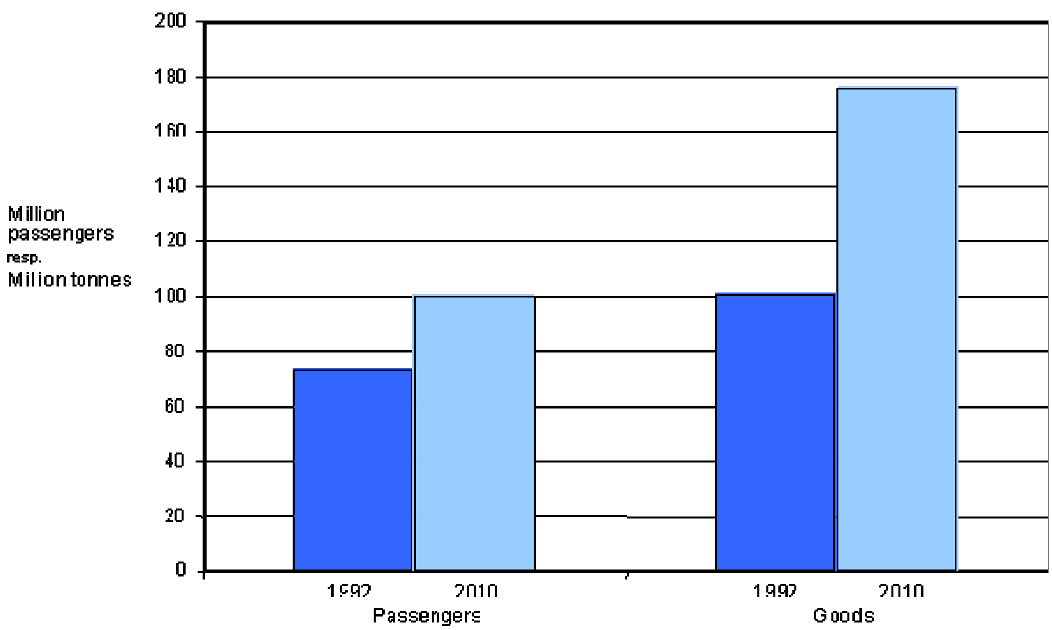
An avalanche growing: transalpine goods transport 1970 - 1998



Source: LITRA (2000), Alpenquerender Güterverkehr, Datentabelle, http://www.litra.ch/Ausw_D/Vadem/alptrst99.htm#D, Bern.

Transit of goods through the Alps has more than quadrupled between 1970 and 1998, increasing from 27 million tonnes to over 125 million tonnes annually. Most of this increase was absorbed by road traffic. While in 1970, rail transit rail was three times heavier than road transit, this ratio has since been reversed: in 1998 road transit accounted for two times more goods than rail.

Forecast for transalpine passenger and goods transport



Source: Prognos AG, Regional Consulting and ISS (1997) *Study of the Development of Transalpine Traffic (Goods and Passengers) Horizon 2010,* Basle, Vienna and Paris.

Owing mainly to general economic growth and increasing European integration, transit of both passengers and goods through the Alps is expected to grow in future. This is the background for the political move to increase rail transit capacities (new tunnels) in order to shift goods transit from road to rail.

Crossing the Atacama Desert: a link from the Pacific to the Atlantic

The Atacama Desert in the central Andes of northern Chile is one the driest places on Earth. It ranges from sea level to a mountain plateau at 4000 m with peak elevations as high as 6700 m. Although it is an extremely hostile environment for humans, the Atacama Desert is economically attractive because it hosts some of the world’s largest deposits of copper, gold, silver, and lithium. It also occupies an important geopolitical position between Chile, Argentina, Bolivia and Peru, and has a long and unique history of trade and traffic.

The location of the Atacama Desert between the Pacific and the Atlantic coast, its vertical structure, and the contrast between very poor food and water resources but very rich metal ore deposits have meant that it has always been an area with intense exchange involving goods, people and cultures. While the central Andes were an area of economic integration from pre-Inca to Hispanic times, the emergence of nation-states in the 19th and 20th centuries resulted in the creation of borders, disagreement about these, and periods of conflict. Strategic routes between Argentina and Chile were temporarily closed during the 1970s and 1980s when these countries were ruled by military governments, but there has since been a continuous effort to re-open these important transportation routes.

Developing high-capacity corridors for access and transit

The Peace and Friendship Treaty of 1984, restoration of democracy in both countries, globalisation of markets, foreign investments, and the emerging economic integration of South America have led to a remarkable economic development of the Atacama Desert, requiring new traffic and transportation infrastructure. Chile and Argentina established integration forums and prioritised 13 passes for trans-border infrastructure development. A visionary development plan, *Corredores Bioceánicos*, aims to link the countries of southern South America with harbours on the Pacific and Atlantic coasts, making their economies accessible to the Asian and European markets. As high-capacity infrastructure was needed to facilitate the exchange of goods, shorter transportation routes along the *Corredor de Capricornio* were designed at altitudes up to 4800 m across the Desert. However, this remained a major technical challenge for various reasons. Though this area is extremely arid, very rare heavy rainfall causes serious damage and can cut roads. The high elevation areas receive more than 300 freeze-thaw cycles per year; yet little is known about the long-term effects of frost-action in the area. Also, the area is tectonically very active and earthquakes are frequent.

Since 1990, bilateral agreements between the governments of Chile and Argentina have led to coordinated infrastructure investments on both sides. In northern Chile and north-western Argentina, the new Paso Jama road with full pavement was constructed for $81.9 million and inaugurated in January 2000. Goods are transported mainly west-east from the 'duty free' harbours of Iquique in Chile to Argentina, Paraguay, Brazil and Uruguay. Parallel to the road, two natural gas pipelines, 941 and 876 km in length, were built to transport energy west-east from the lowlands of Argentina across the Andes to newly built power plants on the Pacific coast in Chile. High voltage power lines bring the energy back to the metal mines and urban centres in the Atacama Desert. New harbours on the Pacific coast are under construction, to facilitate import of goods from the Asian market, and export of products from rapidly expanding metal mining. Since these developments are very recent, and analogues in the region are missing, many questions remain to be answered regarding costs and benefits for the local population and impacts on the mountain ecosystem.

Martin Grosjean and Marcela Espinoza

From parrot feathers to cows and cars: fluxes of goods across the Atacama Desert

The Atacama Desert has a very long tradition of trade. Feathers of east Andean parrots in archaeological sites on the Pacific coast and marine shells found in the high Andes document trans-Andean exchange of goods for over 5000 years. The Inka road (14th and 15th century) crossed the Atacama Desert north-south, connecting Cuzco to Santiago. In the 19th and early 20th centuries, large caravans of cows (in 1909: 83,870 cows) walked west-east from the Argentinean Pampa across the Andes to northern Chile, as all the food and water for the 70,000 people working in nitrate exploitation had to be imported. The cow caravans stopped when nitrate production ceased before World War II. Today, caravans of second-hand cars from Japan are driven in the opposite direction west-east across the Andes to Uruguay and Paraguay.

Transit, local development, and strategic interests: the Karakorum Highway

(in preparation)

Access road construction in Simen Mountain National Park, Ethiopia

Much of semi-arid northern Ethiopia is densely populated and often affected by droughts leading to chronic food deficits. To connect the remote Janamora district to the national road network, the government has constructed a road from the national highway through the rugged highlands. While it facilitates the transport of relief food and supports the region's development, it also runs partly through Simen Mountains National Park, declared a World Heritage Site because of its unique landscape and high biodiversity, with many endemic species and rare wild animals. Little attention was paid to the negative effects of road construction on the Park's environment.

Impacts of road construction

The road was largely constructed along ridges in order to minimise the number of water management structures, and is therefore much longer than necessary. Its construction used heavy equipment such as bulldozers, with the spoil being tipped down the slopes.

With increasing human activities including grazing and road construction, the undisturbed wildlife habitat greatly decreased. The road also cuts through the corridors connecting the northern escarpment with the ridges and peaks to the south, and destroyed much of the valuable high-altitude forest, mainly formed of indigenous species. Above the timberline, a wide band of fragile, delicate afro-alpine vegetation was destroyed along the road. Vegetation and topsoil were removed from roadside slopes and large quarry pits, exposing them to erosion. Side tipping of spoil caused further damage to forests and grasslands, also decreasing slope stability.

The new food relief centre on the Park border shortened the walking distance for local people by two days. Yet the thousands of people coming to this centre cut trees for cooking and overnight warming. As the road was built with heavy equipment, virtually no income was generated for local people, and they gain less income from tourism because trekking facilities are no longer required, as the Park can be visited by car in a day. No compensation was paid to farmers who lost grazing or agricultural land. Along the road, the establishment of tourism infrastructure and services is a problem since the impacts on biodiversity and wildlife would be negative at every location. The same is true for social infrastructure. The long stretches of road running along the escarpment are dangerous because they are often relatively steep and have sharp curves. The likelihood of accidents has increased, especially during rainy and foggy periods.

Mitigating the impacts

To mitigate the road's environmental impacts, two re-alignments were proposed. Different options were compared according to ecological, socio-economic, and technical/cost criteria. The construction of the re-alignments requires comprehensive soil conservation and erosion protection measures. To avoid unnecessary damage to the fragile ecosystem, all construction will use labour-based techniques, which minimise environmental impacts, decrease costs and dependence on mechanical equipment, and give local people income, expertise, and ownership. This approach has been confirmed by recent government policy for rural access roads. The new road will have a gravel surface which is adequate for the rather limited traffic. It is also narrower, designed to minimise the amount of spoil and its transport.

The re-alignments avoid agricultural land as much as possible. The loss of grazing and agricultural land will be compensated and, since construction will be during the dry season, it will not compete with agricultural activities, which are concentrated around the rainy season. Labour-based road construction will be excellent for local income generation, as the project will be awarded to national contractors, who must recruit only local labour. About half the local people should be able to participate in road construction. Thus, 30-40% of the investment will go directly to them as labour wages, considerably decreasing their dependence on relief food during the construction stage - and later, at a reduced scale, during its operation, as wages will be paid for maintenance by trained labourers. Income from tourism could also be generated for the government, through controlled collection of Park revenues, and for local people, through job opportunities as park guides and staff for the centre, if the authorities establish a Park centre and gate.

Stakeholder participation will be encouraged from the beginning, and institutionalised as a suitable forum for discussions concerning the different actors and project issues. It will provide opportunities to inform the local stakeholders about the project's objectives and schedule, and of the necessity for their active participation.

Urs and Ruth Schaffner

Criteria for access road projects in Yemen

In Yemen, the Social Fund for Development (SFD), a national non-governmental organisation financed by major donors such as World Bank, European Union, and Arab Fund, has an interesting approach to assess the viability of rural access roads. They use a mix between quantifiable and unquantifiable criteria and give each criterion an individual weighting.

Criterion	Weighting (Points)
Poverty level of project area	5
Population benefiting (directly and indirectly)	3
Economic potential/burden of area	3
Access to infrastructure (water supply, education, health)	3
Remoteness	2
Suitability as road network extension	2
Per capita cost of road (US$/beneficiary)	2
Maximum Score	**20**

A minimum of 9 points is required for a SFD road project. The point distribution is decided according to established rules so that the result of the viability assessment is transparent and can be explained to the beneficiaries.

Defining "100% Access"
In Switzerland, an access project is 100% successful when each person in an area is able to reach his/her **house directly by car.** In Ethiopia, the criterion is that the population of an area can reach the road within a **one day walk.**

Road network density of Switzerland and Ethiopia

	Switzerland	Ethiopia
Area (km^2)	40,000	1,100,000
Population (million)	7	55
Length of road network (km)	70,000	24,000
Road length/area size (km/km^2)	1.75	0.02
Road length/population (m/person)	10	0.44

In terms of area, Switzerland’s road network is nearly 100 times denser than Ethiopia’s. In terms of population, it is 23 times denser.

Human power instead of machines: rural access roads in West Flores, Indonesia

For the 100,000 people living in the villages of the mountains of Manggarai District, West Flores, Indonesia, an area with considerable agricultural potential, roads are vital for survival. An all-year road link guarantees access to markets, hospitals and higher education, and is crucial for providing communities with fertilisers, construction material for houses, installations for drinking water supply, and other basic goods. However, road construction in such tropical mountain areas requires specific design and construction methods. Road construction started in 1985 and was completed in 1997. In 1994, a new component of supporting traditional self-help community efforts in building village roads and motorable tracks was started.

Designing and building the roads

The development of design standards involved consideration of not only the mountainous topography, the soil conditions, extensive rock outcrops, and the tropical climate, but also an average daily traffic of 20-30 vehicles with a maximum main axle load of 6-8 tons and a maximum speed of 30 km/h, and the use of labour-based construction methods. Based on these design conditions, the four main characteristics of the roads are dry-stone retaining walls, a comprehensive drainage system, strongly built structures, and a hard-wearing carriageway.

A labour-based road construction project, with several hundreds of labourers spread over several kilometres of road, needs careful planning and organisation. The work is split into a number of clearly defined working steps with specific and easily controllable construction activities. To secure high construction quality, a number of simple but very effective aids are used. These include checking the correct shape of slope, ditch, and foundations with wooden templates; and using pegs and string lines to guarantee the correct size of retaining walls, structures and carriageway, and a simple wooden clinometer to check the longitudinal alignment.

Benefits for the region

In total, 180 km of stone-paved roads and 40 km of earth roads were constructed, together with six reinforced concrete bridges, two stone arch bridges, and 30 major culvert-drifts. The average construction cost for stone-paved roads, including an allowance for free community labour, was US$24,000/km. Compared to the standards of existing transport routes on Flores Island, the roads are of exceptional quality, and thus most roads remain in good shape although an effective road maintenance system was not established.

The construction work required almost a million paid working days. Access to the District capital, markets, hospitals, and schools have improved greatly for the villages near the roads. Prices for farm produce and local handicrafts have increased. Supplies of consumer goods have improved, and prices have decreased. As a result of these economic improvements, the number of new or renovated houses along the roads is growing.

Hundreds of villagers were trained on the job as workers and craftsmen, and surveyors and foremen were trained for 17 Sub-districts. Many villages near the roads have undertaken their own road projects without external assistance, achieving satisfactory results. Supporting such traditional community self-help efforts, the additional project component achieved the construction of more than 100 km of village roads by self-help labour, the general realization of the need of a proper road survey by the local leaders, increased demand for the transport of passengers and goods, and requests from four neighbouring districts for support.

Peter Hartmann

Stages of labour-based road construction, West-Flores, Indonesia

- setting out the road alignment
- clearing bushes, trees, and other vegetation, and removal of boulders
- excavation to roadbed level by cutting out the existing side-slope - work that is carried out voluntarily by communities and usually needs adjustment
- general earthwork, including the correction of the dug road bed, adjustment of the backslope and removal of boulders
- construction of dry-stone masonry retaining walls with large stones collected locally, and a backfill of well-compacted gravel
- laying of culverts regularly spaced along the road, and construction of necessary structures, such as concrete fords, culvert drifts, and bridges
- digging a side drain along the road, including scour checks to reduce water velocity
- excavation of the foundation for the stone paving of the carriageway for stone-paved roads, or excavation of the camber base for earth roads
- laying ca. 30 cm of stone paving, and sealing this with a mixture of gravel, sand, and clay to provide a smoother surface and prevent water from penetrating
- applying finishing work, such as protecting slopes and shoulders from erosion by planting grass; placing of kerbstones.

Bridges for rural access in the Himalaya

For Buddhists, bridge building is a very beneficial activity; it means alleviating other people's obstacles. Thus, trail bridge building has a long tradition in the hills and mountains of the Himalayas. For centuries, narrow gorges have been crossed with simple log or rope/cane bridges, bamboo arch bridges, skillfully constructed cantilever bridges, iron chain bridges, and bamboo/cane bridges. Most of these traditional bridges could not be crossed by animals, had a limited span of less than 50m, and very often had to be dismantled before the onset of the monsoon to prevent them from being washed away.

In the early 1960s, Helvetas, a Swiss NGO, actively supported the construction of a few suspension bridges over Nepal's Marsyandi River. In the 1970s, this led to the Suspension Bridge Project, which pioneered a technology for suspended cable and suspension foot bridges, based on traditional local bridges. The Suspension Bridge Division (SBD) was created as the government organisation responsible for trail bridge building. Similarly, Bhutan's Public Works Department initiated a country-wide pedestrian bridge construction programme in the 1970s. In the 1980s, the two trail bridge programmes started intensive exchange of experiences, and the synergies led to the optimisation of technologies. A series of manuals helped build up local capacities in both countries, and streamlined the planning, survey, design, construction, and maintenance of trail bridges.

Bridges in Nepal: an overall concept and privatisation

SBD was mandated to construct bridges on main trails with national or regional importance. Planning, survey, design, supervision of construction and maintenance were done by their own technical staff, and all steel fabrication works and civil construction was contracted to private contractors. With the development and introduction of the Main Trail Concept, following an extensive main trail study, a rational basis for planning, monitoring, and decision making was established.

During the 1990s, bridge survey, design, and task implementation were successfully privatised, improving both efficiency and effectiveness. New funding mechanisms, such as ex-post financing, and the introduction of construction turnkey packages have been introduced, significantly simplifying financial management and administration. These measures led to substantial reduction of overhead costs in relation to the overall project cost.

In the late 1980s, a maintenance concept for main trail bridges was developed. Over the years the concept, consisting of major maintenance and routine maintenance, has been gradually improved, and an illustrative instruction manual has been prepared. Major maintenance is executed in partnership with the districts through cost sharing, whereas routine maintenance is carried out under the bridge warden scheme: every bridge is assigned to a bridge warden.

Apart from the main trail bridges, there is tremendous need for local bridges. Several attempts were made to assess existing local bridge building know-how and assist it where possible. In 1989, the pilot project Bridge Building at the Local Level (BBLL) was launched under SBD, with the main objective to "reactivate, promote and support people's problem solving and self-help abilities for local bridge building". Various support approaches and designs appropriate for local bridge building were developed and tested in different districts. Following the encouraging pilot phase, BBLL gradually expanded its activities in terms of districts covered and bridges supported. Over the last 10 years, the project has proven that its basic concept for supporting local bridge building is effective and successful. Most important is a good and serious initiative on the part of the local communities.

Bridges in Bhutan: intensive community involvement

Bhutan's Suspension Bridge Programme (SBP) has always been characterised by intensive community participation, from planning, through implementation of construction work, to routine maintenance. In contrast to the Main Trail Concept in Nepal, prioritising of bridge sites has been decentralised to the communities. The users of the future bridges are involved in planning and bridge building from the very beginning.

Since the private sector has been quite weak, it was only involved in the fabrication of steel parts. Civil construction work was carried out by villagers under the supervision of technical staff from the respective district. Planning, survey, design and overall supervision are still carried out by SBP staff. In the absence of private engineering capacities, and as a part of the government's decentralisation policy, efforts are underway to enhance the capacities of technical district staff in order to decentralise survey work to the districts by 2002.

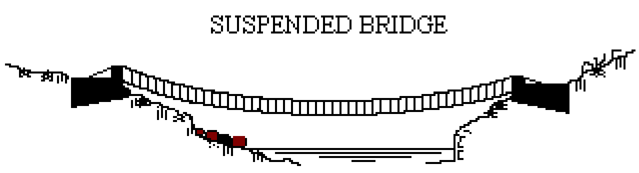
Franz Gaehwiler, M.N. Lamichaney

Trail bridge building in Nepal and Bhutan: number, size, and cost

	Nepal		Bhutan
	SBP	BBLL	SBP, since 1984
Number of completed bridges (per	491	700	168

31.12.00), thereof: suspended suspension steel truss other types	264 212 15	699 1 0	103 51 5 9
Average span of bridges in metres (suspension and suspended types)	95	56	66
Average cost of bridges in US$ (suspension and suspended types)	29’900	6’000	13’700
Average cost per metre span in US$ (suspension and suspended types)	315	100	206

Explanation of abbreviations and acronyms: see main text.



Graphic depiction of a suspension and of a suspended bridge, the two most widely used construction types for trail bridges in the Himalaya (courtesy F. Gaehwiler).

[Image not available]

Tibetan saint Thangton Gyelpo, who was also called the Iron Bridge Builder, built many iron chain bridges in Tibet and neighbouring countries. Some of the bridges still exist today. (courtesy F. Gaehwiler)

Rope ways for mountain tourism and development

In mountain areas, where the landscape is dissected by deep valleys and large differences in altitude have to be overcome, rope ways can provide a cost-effective alternative to railways, roads, and bridges for ensuring public transport links to and from remote mountain areas, securing flows of basic goods, and assuring transport of local products including crops, animals, and bulk commodities such as timber and minerals.

The origins of rope ways go back to ancient times, as shown by Chinese ink-paintings from the 3rd century BC. The invention of the iron cable in the early 19th century and the age of industrialisation and bulk transportation led to a boom in rope way development for the transport of goods. By 1910, over 12,000 large rope ways for raw materials and goods existed worldwide, including such gigantic installations as a 35 km rope way for transporting gold ore in Argentina, over an altitude of more than 3500m. Most of these rope ways have now been replaced by road and railways. Rope ways for passenger transport were first used in larger towns, forming part of the emerging urban public transport sector. San Francisco's cable cars, built around 1870, are reminiscent of this development; most other systems have since been replaced by tramways and buses.

A key element of mountain tourism

In mountain areas, the great expansion of rope ways was linked to the emergence of winter tourism in the 1920s, and especially since the 1950s, when mass tourism gained momentum. There are now over 10,000 installations in over 100 countries worldwide, including a wide range of technical systems such as funiculars, cable cars, gondolas, and chair lifts. Most of today's rope ways are used for passenger transport in tourism, and are largely in mountain areas. Without rope ways, the development of the tourism industry in many mountain areas would not have been possible. One example is the tiny state of Andorra in the Pyrenees, which has over 70 rope ways and ski lifts, with a potential transport capacity of over 130,000 passengers per hour. These have been key in making tourism the most important industry and in tripling GNP over the last 30 years.

Rope ways for development

Rope ways also have extensive potential in the developing world. Studies in Nepal suggest that rope ways are cost-effective in comparison with rural roads and bridges - and even with local trails and suspension foot bridges. The location, design, and construction of rope ways require a combination of skills, including those of a transport economist and those of a structural/civil engineer: the first to consider the economic costs and benefits, and the second to identify and build the appropriate structure. If rope ways are to be sustainable, local communities should be responsible for their maintenance. A technical expert with a social development background is thus desirable to advice on the mobilisation and training of local groups or individuals.

H. Dieter Schmoll, David Seddon, Broughton Coburn

Box:

Rope ways – the safest means of transport

Global statistics have proven that rope ways are the safest means of transport – not only in mountain areas. With millions of passengers transported worldwide annually, there have been less than 300 casualties in the last 40 years. (Source: Global Cableway Statistics 1999, University of Stuttgart)

17 years of unfailing service – the Tashi-La rope way, Bhutan
Inaugurated in 1983, the Tashi-La rope way in Bhutan links the remote Kokota valley with the outside world. It ensures the export of timber, fuelwood, and agricultural products, and the import of consumer goods for the local communities. The rope way has been operating without a major incidence since its construction. Passenger transport was discontinued recently pending a major overhaul. The rope way, 5 km long over an altitudinal range of 1500m, has a transport capacity of 800 kg and is run by a 65hp diesel engine – running costs are thus minor. Maintenance, a critical factor for rope way operation, has been in the hands of local residents for many years, they successfully run it as a private enterprise for the benefit of the mountain community. (Karchung Dukpa and Hansruedi Stierlin, courtesy HELVETAS).

Pros and Cons of rope ways in mountain areas

Points in favour of rope ways:

- Construction and maintenance costs for rope ways are lower than for railways and roads.
- Rope ways are much less susceptible to mountain hazards such as landslides, avalanches, and flooding than roads or railways.
- Rope ways provide local communities with greater economic control over trade and transport. Roads provide an easier entry point for outside economic interests.
- Rope ways are environmentally friendly; they consume less space than roads and create less air pollution.

Challenges to consider in rope way construction:

- Owing to their potential to open up inaccessible areas, rope ways can threaten fragile mountain areas, especially if related to mass tourism or extensive exploitation of mineral resources.
- Rope ways require goods to be loaded and unloaded from other means of transport.

According to global rope way statistics, there are 10,747 rope ways, most in the golden triangle of tourism (Japan, North America, Europe). Regional totals are as follows:

Japan:	3069

USA/Canada:	2519
Alpine countries:	3691
All other countries:	1468

Source: Global Cableway Statistics 1999, University of Stuttgart

Animal power: appropriate transport in mountain areas

In many mountain areas, animal power is still the most important means of personal mobility and local transport of goods. Communities are often connected to markets, health centres, schools, and government services by narrow tracks on which horses, mules, donkeys, yaks, llamas, and other animals can carry loads or be ridden. Mountain communities are often disadvantaged, with few income-generating options. Animal transport can be an affordable way to collect supplies, market produce, and engage in sustainable livelihoods. In developed countries, people are choosing animal power for its ecological benefits.

Appropriate technology with ecological advantages

Animals were once used everywhere for short- and long-distance transport. Now, motorised vehicles are used for long-distance transport where roads exist. Yet animal power is convenient and affordable for carrying small loads: water and fuel for household use; manure, fodder and crops on the farm; and crops from the farm to the market or main road. Animal transport complements long-distance motorised transport by providing local supply and distribution.

Animal power is a natural, renewable energy source. Animals consume local feed, reproduce themselves, and supply valuable manure. Draft animals cause less pollution and environmental damage than motorised alternatives. Animal power is widely available in mountain regions, is generally affordable by rural people, and helps develop local trade. It is labour-intensive and provides valuable employment, particularly in tourism.

Advantages of different transport animals

Horses are often perceived as the most effective transport animals. They are used for riding, carrying and, where tracks or roads exist, pulling carts. In temperate climates and in remote mountain areas they have high economic and social importance, and they are often expensive. They need high levels of management and feeding.

Donkeys are increasing in importance in many places. Though smaller than horses, they are very hardy, reliable, and sure-footed. Donkeys are low-risk animals: cheap, good survivors, and seldom stolen. They are easily managed by men, women or children, and often preferred for domestic and small-scale transport. In the highlands of Ethiopia, five million donkeys carry fuel wood, building materials, fodder, and goods.

Mules are bigger and stronger than donkeys, hardier than horses, and very sure-footed. They are used for commercial pack transport and trekking. However, the need for cross-breeding means they are often in short supply and more expensive than horses.

Oxen are mainly used for tillage and pulling carts, and sometimes for riding and pack transport in humid mountain areas. Yaks, and crosses between yaks and cattle, are important pack animals in the Himalaya. Llamas carry small loads in the high Andes. Camels are used for transport in the mountains of Central Asia, the Sahara, and the Middle East.

Recognising the importance of animal power

Few government officials consider the importance of animal power in the mountains. The topic is omitted from their training. As they may be unaware of key issues, there is need to increase awareness of the benefits and possibilities of maintaining or expanding the use of transport animals, complementing motorised transport.

Pack saddle technology can be simple. Good designs protect the spine, improve efficiency, and avoid animal suffering. In areas where people overload animals, participatory programmes of education, supported by legislation and enforcement, are required. While cart technology is often overlooked in mountain areas, as riding and packing are more important, carts can provide valuable additional capacity for on-farm and village-to-main-road transport.

Many mountain regions have military significance, and pack animals have often provided armies in remote areas with reliable, all-weather, day-and-night transport of supplies. Outflanking by crossing mountains with animals proved as effective in the late 20th century as in previous eras, with donkey transport proving crucial in military campaigns in Ethiopia and Eritrea.

The future: an important role for networks and supporting organisations

As road networks will remain limited in most mountain areas, feeder transport will continue to depend on human and animal power and all-terrain vehicles. In poorer mountain areas, sustainable livelihoods will continue to depend on animals for local supplies and market access. As men seek work in cities, the responsibilities of women for household transport will increase. In richer areas, the ecological and aesthetic advantages of animals will ensure their continued use. Eco-tourism, using horses and mules, is likely to become increasingly popular.

The remoteness of mountain regions means that users of animal transport find it difficult to exchange ideas and innovations with people in similar situations. Networks and supporting organisations can encourage the exchange of experience and help people collaborate to improve technologies and systems of use.

Paul Starkey

Using communications technologies to promote access for mountain people

Mountain people and organisations have many common characteristics. Among these are their marginality – they are barely on most national political agendas; their limited access to public resources, including communications and other infrastructure; and their isolation both from one another and from much of the rest of society. Another great challenge faced by mountain areas around the world is finding ways to keep their most creative young people, through providing relevant higher education to scattered and not very accessible communities. Modern communications technologies can be the key to responding to such challenges.

The Mountain Forum – An innovative global network for information sharing

The Mountain Forum was created in 1995 through the collaboration of non-governmental organisations (NGOs), universities, multilateral agencies, and the private sector. This rapidly-growing global network for information exchange, mutual support, and advocacy for equitable and ecologically sustainable mountain development and conservation links over 2,000 individual members and 50 organisational members in over 100 countries. Its main means of information sharing is the Internet, which is rapidly expanding in mountain areas. Its facilities include:

- 15 discussion lists, for the world and individual continents, on diverse mountain topics;
- an interactive website with membership services, information on events, an on-line library, and links to other networks;
- electronic conferences, in which participants send in and respond to case studies on weekly themes. Contributions are then synthesised into published reports.

A growing global mountain community linked by the Internet
Since its launch in June 1996, Mountain Forum has steadily added members and now lists over 2000 people (December 2000). Of these, 26% are mountain inhabitants, 68 % are professionals working in mountains or on mountain issues and 28% are visitors or users of mountains.

The Mountain Forum coordinates its activities through a global secretariat, a global information server node, and regional nodes for Africa, Latin America and the Caribbean, Asia and the Pacific, and Europe. The European Mountain Forum has regional sub-nodes, hosted by local NGOs. While English is the dominant language, communication in Latin America is in Spanish. In Europe, French and other Alpine languages are used widely; in the regional sub-nodes, the use of regional languages is critical.

To encourage Internet use, the Latin American node has organised workshops in many Andean communities. Yet not everyone has access to the Internet, and available information may not be in languages or jargons which can be easily understood by those who require it. Consequently, the global and regional nodes provide information using more traditional media, such as printed documents, telephone, and fax. As well as sharing knowledge, information, and experiences, the Mountain Forum provides support and advice. In these ways, it facilitates dialogue and information exchange between mountain communities and decision-makers, and gives mountains a home base on the Internet.

The Mountain Forum: success stories in exchange

Examples of successful transfer of experiences and information have included:

- development of a mountain bike trail network in Mexico
- forest legislation in Nepal
- community conservation in South Africa
- human waste management in the USA
- snow leopard conservation in Pakistan
- participatory resource management and planning in Papua New Guinea
- management of mink in Romania
- a code of conduct for tourists in Peru
- ropeways and road development in mountains
- issues surrounding cable car development in Scotland and Peru
- mountain tourism exchange: Peru and Nepal.

Using new technologies to create a regional university: The University of the Highlands and Islands, Scotland

Most universities are in cities outside the mountains, and even those in mountain valleys commonly focus on subjects which are academic and not directly relevant to sustainable mountain development. The University of the Highlands and Islands project (UHI) explicitly addresses such regional needs, using modern information and communications technologies to increase access to, and participation in, lifelong learning across northern Scotland, thus fostering sustainable development and supporting the region's diverse cultural and linguistic identities. The UHI partnership brings together 15 academic partners - further education colleges, research institutions and specialist colleges – to deliver and support undergraduate and postgraduate courses and research activity. There are also over 60 'learning centres' in small communities in northern Scotland.

UHI courses focus on regional needs, attracting students with an interest in the challenges facing dispersed communities with rich cultural histories and diverse natural resources. Eventually, internet and video teaching will permit students to study for degrees from most of the academic partners and learning centres. Unlike most universities, most students are not school leavers; two-thirds are 'mature' students, over 26. Many have families and jobs, and have studied at university previously; about half study part-time. Courses are offered in modules, allowing flexibility in progressing toward degrees.

Video-conferencing, which allows people in different locations to see and speak to each other across any distance, is central to UHI's operations. While half of the video-conferences are for teaching, the technology is vital for effective functioning; to avoid huge transport costs and time wasted in travel, most committee meetings use this facility. A key element is the library: all resources at all academic partners can be identified and requested on-line via the UHI Intranet. Gradually, a dynamic learning environment networked across the Highlands and Islands, with links to learning communities beyond the region, is being created.

Elizabeth Byers, Alejandro Camino, Martin Price, and Simone Nelson

The potential of Internet marketing for remote mountain areas

Among the greatest potentials for economic development in mountain areas are high-quality products which can only be produced under specific local conditions. Yet producers are far from potential markets which, using appropriate packaging and delivery, can be anywhere. Internet marketing can be a cost-effective solution. For example, Dundonnell Smoked Salmon, operating from a small lakeside farm in the remote Western Highlands of Scotland, relies on its webpage to generate 30% of its sales. Over four years, the use of the internet resulted in a 30% increase in sales.

4. CHALLENGES WITH REGARD TO ENERGY AND TRANSPORT DEVELOPMENT IN MOUNTAINS

(In preparation - suggestions

Notes to readers

This is a draft paper presented at the Annual Conference of UN Commission on Sustainable Development, 2001.

For more information go to:
Thomas Kohler
University of Berne
Centre for Development and Environment
Hallerstrasse 12
CH-3012 Berne
Switzerland