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Research on Mountains and Global Change

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1 A major research field of the Institute of Geography, Berne

Mountains and their highland-lowland interactions have gained increasing attention during the past two decades, both as an object of research and of development. The UN Conference on Environment and Development (UNCED) in 1992 put mountain systems on the international and national political agendas. This recognition of mountains, and of the need to promote sustainable development in mountain areas, was the result of intense research in many mountain areas. Swiss universities, including the Institute of Geography at the University of Berne, were present in Rio de Janeiro and were actively involved in lobbying for Chapter 13 of Agenda 21. The International Year of the Mountains IYM in 2002, exactly ten years after UNCED, was the result of continual activity in research and creation of political awareness, which also saw a great deal of lobbying for mountains by the Swiss Government at the international level.

Mountain research at the Institute of Geography has been a focus for many decades, the research spectrum ranging from the Swiss Alps to mountain systems abroad, be it the Mediterranean mountains, the African mountains, the Andes, or the mountain systems of Asia. In 1990, the Institute defined mountain research as a major field of its activities. Methodologically, the Institute departed from mono-disciplinary studies in the 1960s, carried out interdisciplinary approaches in the 1970s, applied more participatory approaches in the 1980s, and finally, developed transdisciplinary methodologies in the 1990s. The latter are still an important component in programme cycles, and may be considered a central approach of the Bernese Institute of Geography. The continuous evolution of these approaches, both in Switzerland and abroad, culminated in the successful establishment of two Swiss National Centres of Competence in Research (NCCRs) in 2001, namely the «NCCR Climate» and the «NCCR North-South». These long-term research programmes focus on global change and use mountain areas as part of the test areas where multiple methodological frameworks are applied, always complemented by research carried out by the different specialised research groups of the Institute.

Global change research at the Institute focuses primarily on climate change. However, in the sense that the Institute uses the term, global change is also seen in terms of clusters of core problems and processes that cumulate from local hazards to globally significant threats. Worldwide examples include processes of land degradation in rural areas and restricted access to and availability of fresh water. Equally important are inadequate environmental sanitation in centres of human activity, human health problems and limited health services, and the lack of potential to alleviate poverty and secure better livelihoods autonomously. Global change can also refer to urbanization, global migration, and geopolitical turmoil. For example, change in the former Soviet countries of Eastern Europe and Central Asia led to social and political instability in mountain areas. Further, conflicts – particularly in resource management – often originate in inadequate policies aimed at reducing institutional incompatibilities and barriers. Hence, problems of global change occur in virtually all nations worldwide, and have especially serious consequences in mountain areas and developing countries.

The Institute's research in mountain areas has a strongly developed bio-physical focus, including climate and weather studies (cf. 2.1), hydrology, soil science, geomorphology, remote sensing and forestry (cf. 2.2). In human geography, the focus is on urbanisation and economic change (cf. 2.3), social and political change and gender relations (cf. 2.4). In terms of the geologic time scale, several research groups focus on palaeo-studies, i.e. a time span of up to 1 million years, with the predominant focus on the Pleistocene and Holocene periods (Table 1). But the Institute also specialises in multidisciplinary, interdisciplinary and transdisciplinary approaches – the latter transcending the natural and social sciences and including research on the local knowledge of non-scientific agents and institutions (cf. 2.5 and 2.6, and Table 2).

As part of its research activities, the Institute developed methodological concepts and tools, particularly in its long-term programmes «Man and Biosphere» in the Alps (MESSERLI 1986), and «Sustainable Regional Development» (WIESMANN 1998). Concepts such as «Sustainable Development Appraisal» (HURNI & LUDI 2000) and «Autodidactic Learning for Sustainability» (CDE 1998) offer transdisciplinary methodologies in local to regional contexts. Most of these new approaches and methods are used for integrated analysis of problems and definition of problem solving strategies, not only in mountain areas in developing and transition

Time:	Pleistocene	Holocene	Present day
Alps	X	X	XXX
African Mts	X	X	XXX
Andes	XX	XX	XX
Asian Mts	(none)	(none)	XXX

Legend: X: Individual studies; XX: Projects; XXX: Programmes

Tab. 1: Focus of the Institute's research in different time periods and mountain systems of the world
Forschungsschwerpunkte des Institutes in verschiedenen Zeitperioden und Gebirgssystemen der Erde
Focalisation de la recherche de l'Institut sur les systèmes montagneux dans le monde, durant différentes tranches chronologiques

countries, but also in Switzerland. These approaches have also been found suitable in spatial contexts such as semi-arid areas in transition and urban environments.

Last but not least, the Institute hosts the international, peer-reviewed journal *Mountain Research and Development*, which it took over from its founder, Professor JACK D. IVES, in 2000 (www.mrd-journal.org).

2 A selection of thematic fields of mountain research at the Institute

2.1 Climate change in the Andes and Alps from the Pleistocene to Present

Mountains deflect airflow horizontally and vertically and increase frictional dissipation. In addition, they are important sources or sinks of sensible and latent heat. Important climatological parameters that indicate pressure, temperature and precipitation therefore have high gradients in mountainous areas. Due to their steep relief and great altitudinal range, mountains are also very sensitive to climate change. By analysing appropriate natural archives and reconstructing landscape development, it is possible to gain a relatively precise understanding of climate history, as shown in

the following examples from the Andes and the Alps.

By contrast with marine core samples, there are few continuous climatic archives from the distant past on the continents with medium and low latitudes. One particularly good continental archive is the loess-paleosol sequences currently being studied in north-west Argentina (SCHELLENBERGER et al. 2003). The various paleosols indicate relatively humid periods in the subtropical-monsoonal system of the Andean eastern slope during the last 1 million years, i.e. a period clearly longer than the Pleistocene. The loess in between originates from dry periods. In the Brunhes Chron there are 18 paleosol layers, preceded by 8 paleosol before the Jaramillo sub-Chrone and another 2 during the Jaramillo sub-Chrone. Generally, average soil formation cycles lasted around 26,000 years and 40,000 years, respectively. The fluctuation could have been induced by orbital influences, but this remains speculative until more precise dating is available. Along with frequent humidity fluctuations indicated by the separate soil-loess sequences, variation in the formation of soils points to long-term paleoclimatic change in the direction of drier conditions in the Jaramillo sub-Chrone. These conditions persisted until approximately 700,000 years ago, when the climate became generally more

Approach:	Disciplinary	Multi-disciplinary	Inter-disciplinary	Trans-disciplinary
Alps	X	X	XXX	XX
African Mts	X	X	XX	XXX
Andes	XX	XXX	X	X
Asian Mts	X	X	XX	XXX

Legend: X: Individual studies; XX: Projects; XXX: Programmes

Tab. 2: Emphasis of the Institute's research approaches in different mountain systems of the world
Gewichtung der Forschungsansätze des Institutes in verschiedenen Gebirgssystemen der Erde
Approches majeures de recherche de l'Institut, relatives à différents systèmes montagneux du globe

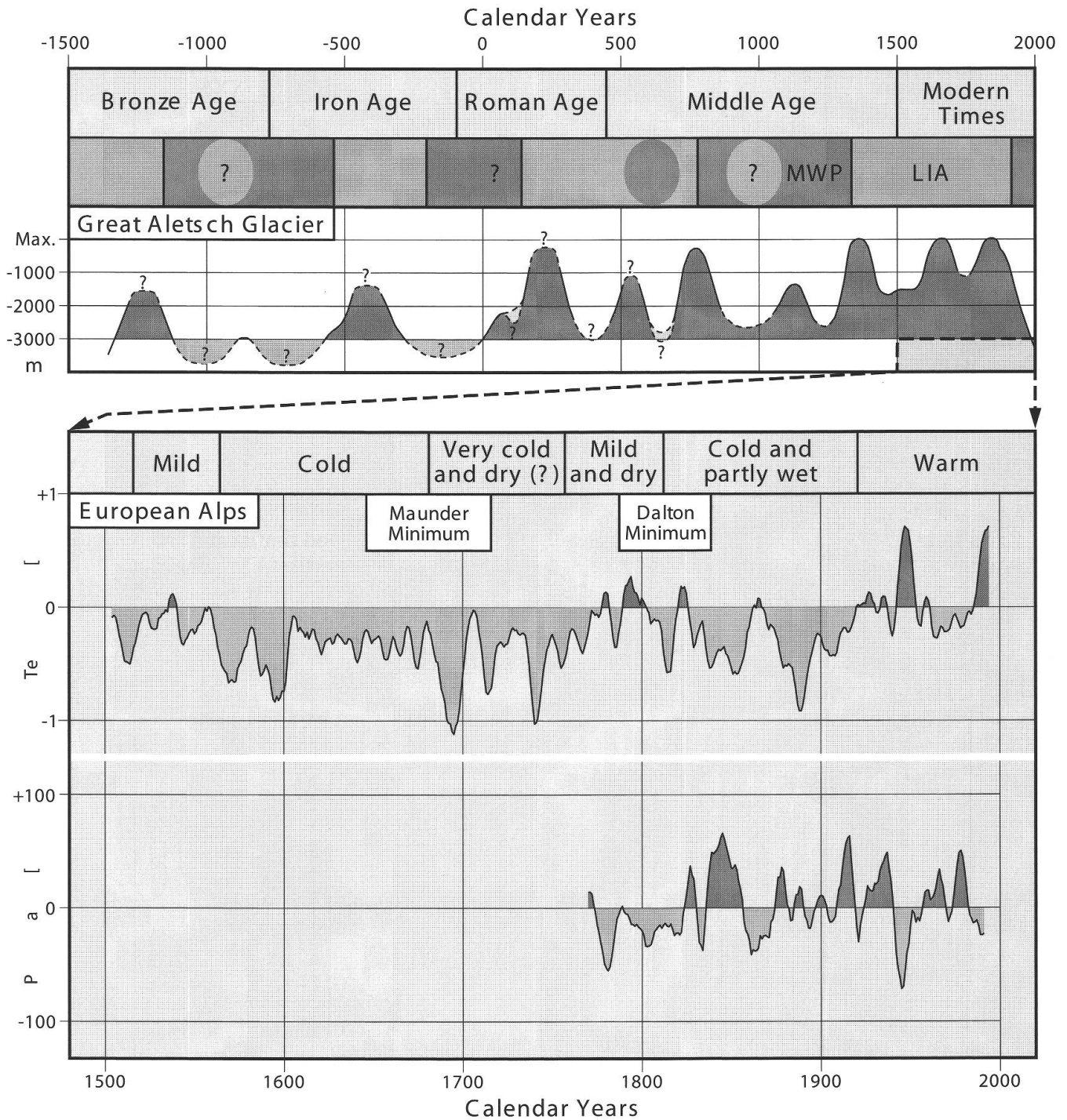


Fig. 1: Alpine climate change in the late Holocene

Explanation: The lower bar in the upper part of the figure shows a break-down of the last 3500 years into cooler (light grey) and warmer periods (dark grey). Historical periods are printed in the upper bar for comparison. The curve underneath shows changes in the length of the tongue of the Great Aletsch Glacier. MWP: Medieval Warm Period; LIA: Little Ice Age (according to HOLZHAUSER & ZUMBÜHL 1999). The bar in the lower part of the figure shows possible climatic classification for the last 500 years. It is based on the mean curves below calculated from grid data, showing temperature (upper curve) and precipitation starting in 1776 (lower curve; according to LUTERBACHER et al. 2003).

Alpiner Klimawandel im Spät-Holozän

Changement climatique alpin durant l'holocène tardif

humid. At the same time marked changes in the climate system are also found on a global scale, e.g. in Chinese loess (HESLOP et al. 2002) and in deep-sea sediments (RAYMO et al. 1997).

A more precise chronological understanding of climate change can be gained from lake sediments. Results are available for the last 10,000 years for the Laguna Aculeo in central Chile (JENNY et al. 2002, 2003). According to sedimentological, geochemical and palynological findings, the lake surface rose to its present level following an early-Holocene dry period with fluctuations. The increase in humidity reflects the growing influence of west wind circulation in Mediterranean Chile. Synchronically, the insolation curve is found at 30°S, indicating possible orbital influence.

Figure 1 gives a very differentiated picture of Alpine climate change in the late Holocene. In the top part of the diagram, the light and dark gray areas in the horizontal bar indicate cooler and warmer periods. They were qualitatively deduced from natural climate archives on the basis of various time series (lake sediments, lake water levels, pollen profiles, and glacial fluctuations). It is remarkable that in the 3500-year-period shown in the diagram there were quasi-periodical alternations between warmer and cooler periods. Among other things, there is a striking contrast between warming during early Roman times and cooling during the Little Ice Age. The questions of how warm the medieval warm period really was and which processes led to these pronounced fluctuations are currently being examined.

The temperature fluctuations shown in the lower part of Figure 1 (last 500 years) illustrate the marked transition from the Little Ice Age to the Present. They are based on a digitised data set collected on the basis of numerous time series from natural archives and data from historical documents (WANNER & LUTERBACHER 2002). According to first model studies involving paleoversions of global models, the cooling may have been caused by fluctuations of solar intensity (e.g. during the Maunder Minimum), along with an accumulation of explosive, predominantly tropical volcanic eruptions, e.g. shortly before 1600 or after 1800. Furthermore, the cold and humid periods in the 19th century and the transition to the modern warm period, with the warm and dry 1940s and the clear change to a global warm phase after 1975, are particularly interesting from a dynamic point of view.

2.2 Water, soil and natural hazards in the Alps

The two «United Nations International Years» of Mountains (2002) and Freshwater (2003) have underscored the major importance of the mountains as a source of global freshwater. A study carried out by

the Research Group Hydrology quantified the role of mountains as water towers, based on 19 river catchment areas around the world (VIVIROLI et al. 2003). In arid and semi-arid areas, mountain runoff accounts for between 60% and 95% of the total runoff in the lowlands, while in humid areas this figure is as high as 60%. Large-scale irrigation systems rely on lowland rivers fed by mountainous areas. 70% of all water consumed by humans is used for irrigation.

Despite their great hydrological significance, mountains are still one of «the blackest of black boxes» in the hydrological cycle (KLEMES 1988). The lack of a comprehensive series of measurements makes it difficult to examine their complex hydrological situation. Switzerland has one of the world's most thorough measurement networks. Thus it is all the more surprising that even in Switzerland researchers still face difficulties in obtaining a detailed understanding of the hydrological regime of montane catchment areas. One reason is that precipitation data are often flawed (SCHÄDLER & WEINGARTNER 2002). However, the «Hydrological Atlas of Switzerland» produced by the Research Group Hydrology (WEINGARTNER & SPREAFICO 1992, 1995, 1997, 1999, 2001, 2002) has substantially enhanced knowledge of the hydrology of Switzerland.

From a hydrological point of view, mountain regions not only have great potential but also frequently are sources of hazards and risks. One problem focused on by the Research Group Hydrology is the development of methods to estimate flood runoff in catchment areas where little or no runoff data are available which is the usual case in daily practice. An electronic data processing tool was developed in early 2003 that makes efficient flood assessment possible (SPREAFICO et al. 2003).

Flood assessment frequently still relies on empirical or statistical approaches. It is therefore necessary to better integrate knowledge of processes related to runoff development into these methods. Process-related knowledge can only be gained in comprehensive terrain studies based on several different methods (mapping, sprinkling, tracer experiments). The test areas run by the Research Group Hydrology in collaboration with other institutes and institutions in Leisigen (Spissibach), in the Emmental (Sperbelgraben) and in the Himalayas (five areas in Pakistan, India, Nepal, and China) are of great significance, not only in this respect but also as «training sites» for a large number of students.

The ways in which water reacts with its various surroundings on its way from snow and rain in the high mountains to streams in the lowlands constitutes an ongoing field of research that occupies various research

groups at the Institute. The Soil Science Department is concerned with rapid infiltration and the generation of runoff at the scale of soil profiles (GERMANN et al. 2002), with the aim of assessing the impact of various types of soil and land use on hydrological processes.

Land use in the Alps has changed considerably during the last two centuries. For most of the 19th century there was enormous economic pressure on traditional milk, meat and cheese production in the Alps. This led to uncontrolled expansion of meadows and pastures, with detrimental effects on forests (GERMANN & HOLLAND 2001). As the Swiss forest authorities are also charged with managing forests as barriers against avalanches, landslides and torrential runoff from first-order mountain streams, they set up a reforestation programme which led to the reforestation of about 40,000 ha of land (mostly pastures). Among other things, the underlying justification for this was the assumption that forests have a significant effect on flood mitigation. Quite often these projects met with fierce opposition from landowners.

By contrast, the last third of the 20th century saw a dramatic retreat of agriculture from the high mountains. This ultimately led to the expansion of wooded areas below the timberline, at an estimated rate of about 5,000 ha annually for the last 15 years (GERMANN & WEINGARTNER 2003). Thus investigation of the impacts of highly dynamic land use changes on the formation of runoff will continue to challenge students and the faculty alike.

The Institute's research group on Applied Geomorphology and Natural Risks focuses on development, modification, and application of methods for integral assessment of mountain hazards. Basic research deals with the manifold processes in mountain torrent systems, and is carried out in close collaboration with the Research Group Hydrology (operation of the torrent experimental catchment Spissibach, Leissigen) and with related slope processes such as landslides and erosion (LIENER 2000). Other research focuses on rockfalls, especially rockfall-forest interrelations, and on periglacial systems in the Alpine zone, e.g. through operation of a small test area near the Gemmi pass (IMHOF 1996, KRUMMENACHER et al. 1998).

This basic research, as well as compilation of findings by other research groups, aims at the development of pragmatic and easily applicable tools for hazard assessment, especially in the context of mountain torrents and debris flows (GAMMA 2000). These projects are carried out in close collaboration with the Swiss Federal Administration and companies in the private sector (HEINIMANN et al. 1998). Other applications

are concerned with the development of measurement tools and procedures for periglacial and permafrost research (KRUMMENACHER et al. 1998, 2003). Risk management in the context of mountain hazards is a more recent focal point of research and application, e.g. analysis of cost-benefit aspects of measures (technical, forest, urban planning, etc., cf. ROMANG et al. 2000) to combat mountain torrent hazards, or organizational aspects of integral risk management (case studies in the context of recent events). Close collaboration with the government, as well as consulting mandates, ensures permanent incorporation of the real world of mountain risk management and related problems and questions (KIENHOLZ et al. 2002).

A major asset of the Institute's research group on Remote Sensing is that it receives and archives NOAA-AVHRR (Advanced Very High Resolution Radiometer) data covering the entire area of the Alps. A major objective of these activities is investigation of environmental parameters (vegetation, snow cover, land surface temperature and aerosol content) over the last 20 years for the entire alpine area. The aim is to analyse at least one data set per day for the group's studies on changes in land surface parameters. Since August 2001 the operational status has allowed reception of all available NOAA passes per day with a reliability of almost 100%. The amount of archived data exceeds the number of 17,000 NOAA-AVHRR images and increases by 5-8 new data taken during 24 hours from NOAA-12, NOAA-14, NOAA-15, NOAA-16 and NOAA-17, respectively. The great advantage of NOAA-AVHRR is that it has been operational without interruption for more than 20 years, using the same sensor configuration. Additionally, one NOAA-AVHRR sensor covers the same region on the earth twice a day, with a swath of 2700 km. These are the best conditions for an operational monitoring system covering the European Alps.

Taking into account how much NOAA-AVHRR data have to be processed to analyse changes in vegetation, snow cover dynamics and land surface temperature in the Alps, it was necessary that an operational processing chain be developed. Since summer 2002 an operational processing chain has been in use which produces, several minutes after the reception of the raw data, information on the vegetation index, snow cover distribution, lake and sea surface temperature, land surface temperature, and aerosol optical depth. Initial results are published or are made available at <http://www.giub.unibe.ch/remsen>.

2.3 Urbanisation and economic change in the Alps

The linkage between urban systems and national economic growth has again become a focus of attention.

Stimulated not only by the work of KRUGMANN (2000) but also by the close attention being given to poles of growth in an increasingly integrated global economy that is also making the most productive locations more isolated, the issue of economic development has again become an item on the agenda of geographic research (GÜSSEFELDT 2001). In association with the «urbanisation» of the Alps, this issue has moved to the centre of our most recent research (PERLIK, MESSERLI & BÄTZING 2001). This recent work suggests that the relation between network and supply functions in the urban economy in particular is of decisive importance. A recent study by PERLIK (2001) shows that the way this relation is shaped will influence future development, particularly of cities in the Alpine region. Hence we can only answer the question raised by RAFFESTIN (1999: 27), «L'avenir des Alpes, passe-t-il par les villes?» in the affirmative.

In their 1993 publication, BÄTZING et al. drew a «new picture of the Alps» that was characterised by the contrast between urbanisation and depopulation of the Alpine region. A study of urbanisation processes by PERLIK (2001) covering the entire Alpine region quantifies these processes and determines various types of urban development, based on the relation between urban centre network and supply functions. The majority of the 240 zones of urbanisation identified in the Alpine region (urban centres and periurban communes) are rooted in small and medium towns – only six of them have an urban centre with more than 90,000 inhabitants. These proportions illustrate not only the marginality of Alpine cities within their respective national system of cities, but also their low demographic potential and the late inner-Alpine development of private traffic infrastructure, which led to more dense settlement only in the second half of the twentieth century. An historical analysis of the development of settlements and cities in the Alps (MATHIEU 1998) likewise indicates a long absence of cities, showing that in 1900 there were only 42 settlements with more than 10,000 inhabitants.

Scientific and political interest in the development of Alpine cities indicates that the numerous small and medium towns or centres in the Alpine region are seen to hold the potential to hinder further depopulation. This is also true of Alpine countries that have so far remained less seriously affected, such as Switzerland or Austria. Correspondingly, Alpine cities play an important role as «stabilisers» of economic development in the reorientation of regional policies in the Alpine region, for instance in Switzerland (MESSERLI 2003). However, our state of knowledge is rudimentary when it comes to enumerating the real comparative advantages of Alpine cities over other locations on a national and international

scale. Correspondingly, opinions differ greatly in the various publications cited (BORSODORF 1999).

A continued examination of development of towns and urbanisation in the Alps is interesting both from a theoretical and a political point of view. From the theoretical perspective, the qualitative and quantitative understanding of the relation between network and supply functions will be particularly challenging. Explanation of growth dynamics and economic differentiation among these cities must involve descriptive and analytical concepts of territorial production and innovation systems, as well as an expansion of the Central Place Theory to take into account the increasing significance of Alpine cities' as residential areas (TORRICELLI 2002). The political significance of such research is implied by the fact that neither the EU nor the Alpine Convention have duly acknowledged the existence and the recent development of Alpine cities. Neither in the European Spatial Development Perspective nor in the Alpine Convention are Alpine cities perceived or discussed as strategic elements of economic and demographic development of the Alpine region.

The coming challenges for research on the future of Alpine cities are thus set out. Given the great diversity of assessments of Alpine cities' specific potentials by various authors, discussion is bound to be interesting. Based on the assumption that regional development in the Alps is substantially influenced by small and medium towns, the region's future needs to be discussed, analysed and strategically interpreted taking into consideration the following pending changes: the new trans-alpine links will create new conditions of accessibility and new traffic nodes that enhance the attractiveness of the Alpine cities as locations for service and specialised industries. Residential quality in terms of cultural, social and medical infrastructure is important not only in a leisure society but also in an ageing society. In this respect, Alpine cities have special qualities that can be developed into real comparative advantages. Due to the change in European agricultural policy, the number of farms in the mountains will continue to decrease rapidly. The green sector (agriculture and forestry) will thus definitely lose its socio-economic support function, in Alpine regions as elsewhere. Agriculture itself will require a supportive socio-economic environment with services and trade. And, finally, we will need to answer the question of which development potentials can realistically be ascribed to the «in-between areas» that are neither serviced by urban centres nor situated near tourist destinations.

This research agenda opens up new avenues of cooperation between economic geography and regional research (MESSERLI and associates) and settlement research (EGLI and associates).

2.4 Mountains as transit and border areas

The Research Group for Social and Political Geography and Gender Studies looks at how social and discursive realities and rules that define agency and influence political decisions relating to space are produced and reproduced, and which individuals or groups are involved in this process. These social rules and systems of meaning, and related patterns of action exhibited by actors, are studied in different contexts and at different spatial levels (from local to global), in order to illustrate the range of possible actions and open them to negotiation.

Their research is also pursued in mountain regions where, owing to the natural environment, social and political processes take place under conditions – particularly fragmentation and remoteness – that are unusual in the plains and lowlands. Without being deterministic, it can be stated that mountain regions in many parts of the world are areas of transit, transition and retreat, where traditional agricultural societies are frequently found, due to a lack of alternatives. Owing to natural conditions, mountains are often less densely settled than plains; they have no large agglomerations of population and no economic or political centres. This leads to a situation in which the peripheral location of mountains – because they have been made to function as political borders – results in many countries in social, economic and political marginalisation, especially where ethnic minorities have withdrawn to mountain valleys. On the other hand, mountains are significant in geopolitical, strategic and international, or at least supra-regional terms. Hence, they are a major focus of interest as transit areas and border regions.

This is the starting point of the group's research: in social geography they focus on investigating constructions of identity and difference, the social attribution of images of the self and the other, and the related power of definition. How are the categories of «we» and «others» developed, regionally and locally, and hence also in mountain regions – categories that usually have their foundations in hierarchical and value-based distinctions? Their empirical studies investigate social and discursive constructions of realities and geographies by individuals in different social groups, in mountains and elsewhere – e.g. by female urban dwellers who go to the mountains to work (BÄSCHLIN & SCHWEIZER), or by the population of a particular area (LANFRANCHI-KLINGLER 2001).

In the area of political geography, theoretical and empirical studies focus on two issues. One is the geopolitical meaning of border areas and the construction of (border and mountain) geographies in views relevant to agency or by the specific activities of different actors (WASTL-WALTER & KOFLER 1999, 2000a,

2000b; WASTL-WALTER, VARADI & VEIDER 2002). The second issue is the question of spatial organisation of the state in political and administrative terms which guarantees that citizens' demands for services are satisfied in as evenly distributed and economically efficient a manner as possible, while also offering people the opportunity for direct participation in the solution of problems that affect them. This is a matter of optimising assignment of responsibility, tasks, and competence, and the financing of state activity at different levels. The group pursues this question within the international scientific community, through WASTL-WALTER's position as Chair of the IGU Commission on Geography and Public Policy, and at the national and local levels (WASTL-WALTER 1996, 2000; BARLOW & WASTL-WALTER).

The third field of research is gender studies. Here, too, the group is concerned with identity and difference, with socially constructed realities, with agency, and with power relations. The specific focus in this area is on gender relations, identity assigned on the basis of gender, and performance and interpretation of gender, together with the corresponding expansion or limitation of potential. Case studies in different contexts provide empirical evidence and help advance the development of theory. Different studies have been undertaken on female labour and the position of women in mountain regions, and of women farmers in the Alps (BIERI & MICHEL 1999; HOLZER 2001; BÄSCHLIN 2003; SIEGENTHALER in prep.).

In each of these areas the research group attempts, primarily by applying qualitative methods, to get a sense of and deconstruct the world views, discourses, norms and rules of different actors that are relevant to agency and space, in order to open them to negotiation and hence to change. Geography can thereby help to reduce prejudice and mitigate conflict, while also clarifying how sustainable development can be advanced in social and cultural terms.

2.5 Conservation and sustainable land management in mountain regions

Protection and sustainable management of natural resources are at the centre not only of agricultural land use in mountain regions, but of all types of human activity. This was extensively illustrated by interdisciplinary research carried out in the Swiss Alps in the 1970s and 1980s, as part of UNESCO's Man and the Biosphere (MaB) Programme (MES-SERLI 1986).

With a view to the paradigm of sustainable development, greater attention was given to issues relating to overuse of natural resources (particularly soil, water and vegetation), while the human factor – including



Fig. 2: Long-term monitoring of natural resource processes to gain a better understanding of the dynamics of global and local change. Catchment runoff and sediment loss are being assessed by the Institute in Maybar, Ethiopia.

Langzeitbeobachtung von Veränderungsprozessen der natürlichen Ressourcen führen zu einem besseren Verständnis der Dynamik des globalen und lokalen Wandels. Der Abfluss des Oberflächenwassers und damit assoziierte Sedimentation werden durch das Institut in Maybar, Äthiopien, erforscht.

Observation à long terme des processus de ressources naturelles en vue d'une meilleure compréhension des dynamiques du changement global et local. Bassins de ruissellement et sédimentation sont étudiés par l'Institut à Maybar, Ethiopie.

Photo: H. HURNI

human interactions with the environment – was increasingly integrated (HURNI et al. 1996). With respect to the natural environment, the focus was primarily on highland-lowland interactions and interdependencies. This is a highly integrated point of view that takes greater account of economic, social, political and institutional issues and aspects, e.g. in relation to the potential for conflict or analysis of development options. The past 15 years have seen a particular expansion in the Institute's geographical areas of activity, particularly through the Centre for Development and Environment (CDE): from Africa to Asia (Nepal, Thailand, Laos, Vietnam), Latin America (Nicaragua, Colombia, Bolivia) and – following the collapse of the former Soviet Union – Central Asia (Kyrgyzstan, Kazakhstan, Tajikistan). The focus in the Alps is still concentrated on the Bernese

Oberland and the new Jungfrau-Aletsch-Bietschhorn (JAB) World Heritage Site, where CDE is an active participant in implementation of the management concept.

A soil conservation programme was initiated in the highlands of Ethiopia in 1981 and coordinated by CDE for almost 20 years (cf. HURNI 1998). This programme produced long-term data on soil erosion, runoff, sedimentation, land use, and new soil conservation technologies, as well as information about the acceptance and productivity of various conservation measures (cf. Fig. 2). A similar programme has been carried out in Eritrea since 1997 (BISSRAT GHEBRU & KOHLER 1999). Conservation and sustainable land management was the theme of an integrated research programme focus-



Fig. 3: Transition in Central Asia leads to a disruption of economic and social systems, with serious consequences for natural resources. Collection of rare wood biomass in high pasture areas as a substitute for fossil fuel is a focus of study by the Institute in the Pamir Mountains of Tajikistan.

Moderne Transformationsprozesse in Zentralasien führen zu einer Spaltung der ökonomischen und sozialen Systeme mit ernstzunehmenden Folgen für die natürlichen Ressourcen. Die Brennholzproblematik in Hochlagen des Pamir-Gebirges in Tadschikistan ist ein Untersuchungsschwerpunkt des Institutes.

La transition en Asie Centrale conduit à une rupture des systèmes économiques et sociaux, entraînant de sérieuses répercussions sur les ressources naturelles. La recherche de rares biomasses de bois comme substituts du pétrole, sur les hauts pâturages, fait l'objet d'études à l'Institut des montagnes du Pamir du Tadjikistan.

Photo: H. HURNI

ing on the Simen Mountains National Park World Heritage Site in northern Ethiopia, for which a concept known as Sustainable Development Appraisal was designed (HURNI & LUDI 2000). Finally, approximately one-third of the experience with soil conservation documented by the World Overview of Conservation Approaches and Technologies (WOCAT), a global programme initiated and coordinated by CDE, was based in mountain regions (LINIGER et al. 2002).

In the area of sustainable management of water resources, the Laikipia Research Programme has operated a comprehensive data compilation network since 1984; the Programme has produced many outputs related to integrated management concepts (WIESMANN et al. 2000). A project carried out on behalf of

the Mekong River Commission, from 1996 to 2001 (BREU et al. 2002), focused on watershed classification, with individual research projects on land use dynamics subsequent to this project phase. A joint CDE-ETH research group on highland-lowland interactions developed options for improved management of natural resources on the eastern escarpment of Madagascar, resulting in a considerable evolution of the stakeholder approach (MESSERLI 2002; BRAND 1998).

Integrated approaches to sustainable mountain development led to application-oriented forms of implementation in the Alps after completion of the MaB programme (WIESMANN 2001). Studies of an agro-silvopastoral mountain ecosystem in the High Atlas of Morocco demonstrated the central role of extensive

goat grazing as a fundamental condition for maintaining high levels of productivity on small irrigated terraces (MASELLI & GEELHAR 1995). Integrated research approaches were applied and tested in different studies in Central Asia starting in 1999, e.g. in connection with communal development in the Tien Shan Mountains (CAMP 2000), improved management of high pastures in the Tien Shan and Pamir Mountains, and sustainable regional development in the Pamir Mountains (BREU & HURNI 2002, cf. Fig. 3). Finally, in the Alps, conservation and sustainable management were themes of central importance in the Entlebuch Biosphere Reserve (HAHN 2002; SCHÜPBACH 2002), and in the Jungfrau-Aletsch-Bietschhorn World Heritage Site the focus was on the process of implementing management concepts.

At the international level, the Institute and CDE participated jointly in a Swiss initiative to promote sustainable mountain development (UNCED 1992: AGENDA 21, Chapter 13). This effort was characterised by an international presence, primarily in the form of a brochure published annually in the «Mountains of the World» series, which addresses such topics as water, tourism, forests, energy and infrastructure, and policy (MOUNTAINS OF THE WORLD 1997-2002).

Efforts to establish links between complementary core areas of competence in mountain research were recently reinforced by the launching of the NCCR (National Centre of Competence in Research) North-South: Research Partnerships for Mitigating Syndromes of Global Change» (cf. www.nccr-north-south.unibe.ch). Thematic, geographical and methodological approaches are currently being further developed and tested in this programme, together with partners in the South and the East. At the core of the programme is the syndrome approach (WBGU 1996). CDE is the lead agency for the NCCR North-South and the two project areas, «Conceptual Framework and Methodologies» (IP1), and «Natural Resources and Ecology» (IP2). Geographically, the programme priority areas of CDE are in the Horn of Africa and East Africa (coordination of IP1), and Central Asia (coordination of IP2). This intensified cooperation at the national and international levels is advantageous for the image of a centre of excellence in the field of research focusing on developing and transition countries.

2.6 Research on syndrome mitigation in mountain regions

The International Year of Mountains 2002 has increased awareness in the general public about the importance of mountain systems and the threats they are facing. The resulting call for integrated perspectives (e.g. MOUNTAIN AGENDA 2002) is based on the observation that global change, when it encounters

specific local conditions, leads to complex problems in mountain development. Global economic and socio-political change is thereby manifested in two general trends (MESSERLI & IVES 1997). First, in developing countries in the tropics and sub-tropics, land use pressure and exploitation of resource-rich mountains and highlands continue to increase. Second, in mountain systems in developed countries, a general pattern of concentration of human activities in narrow, high-potential zones and neglect of vast regions can be observed at various scales. In both cases, general trends meet with a great diversity of ecological and socio-cultural conditions, thus leading to small-scale variation of specific situations and problems of mountain development.

Against the background of these characteristics, the call for more integrated perspectives on mountain development poses a major challenge for research, in particular if it aims to contribute to more sustainable mountain development (UNCED 1992: AGENDA 21, Chapter 13). One of the key problems is that specific approaches and solutions would basically have to be found for every specific situation in a transdisciplinary process. It can be shown that this requirement is a fundamental implication of the concept of sustainable development (WIESMANN 1995). On the other hand, sustainable development can only be meaningfully conceived, planned and implemented at higher policy levels. Correspondingly, approaches and solutions must be found at a more general level. In other words, the «idiographic trap» of sustainable development (HURNI & WIESMANN 2002) is most obvious in relation to mountain development, due to the small-scale variation of situations in mountain regions.

Research that aims to promote sustainable mountain development therefore faces the challenge of bridging the need for situation-specific approaches and the need for generalisation. A possible way out of this dilemma has been indicated by the «Syndrome Concept», originally proposed by the WBGU (1996) and further developed into «Syndrome Mitigation Research» by the Swiss Association of Research Partnership Institutions «SARPI» (NCCR North-South 2000). This research focuses on combinations of problems and potentials in sustainable development and underlying processes, and compares such combinations in specific situations. A cluster of comparable combinations is called a syndrome (e.g. CASSEL-GINTZ 2003). The syndrome approach hypothesises that similarities of combinations (i.e. syndromes) point to similarities in the underlying dynamics and driving forces. Furthermore, this notion of syndromes makes possible generalised pathways of mitigation. These pathways consist of valorisation of potentials and minimisation of the problems of sustainable development.

The NCCR North-South applies the approach of syndrome mitigation research and aims to promote sustainable development, particularly in mountain regions. It thereby addresses problems and potentials of sustainable development at different levels, from local case studies to global overviews. At the same time, it identifies underlying societal, economic and ecological dynamics and processes. At the core of this research are mountain systems in the Central Andes, the tropical mountains of East Africa, the Nepalese Himalayas, the Mekong Basin, and the Swiss Alps (see NCCR NORTH-SOUTH 2003). Development-oriented research in these regions is further supplemented by demand-driven pilot studies on concrete pathways for mitigating syndromes of global change.

In sum, mountain-related syndrome mitigation research by the NCCR North-South combines contextualising and generalising components and, at the same time, bridges theoretical and practical approaches. In this sense it attempts to fulfil the complex challenges posed by the aim of promoting sustainable mountain development. Facing these challenges in mountain research is undertaken with a double focus: (1) to concretely serve mountain regions and their inhabitants, and (2) to draw experience from the model case of integrated mountain research for research on sustainable development outside mountains, e.g. semi-arid areas or urban and peri-urban regions in the case of the NCCR North-South.

Considering the different themes and approaches described in sections 2.1 to 2.5, one could conclude that the double focus claimed for NCCR North-South is applied in all of the Institute's involvement in mountain research: mountains are both an end and a means in the Institute's research.

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