Marburger Geographische Schriften	135	S. 265-281	Marburg 2000

Recent Land Cover and Land Use Dynamics in the Nanga Parbat Area (NW Himalaya): Human-Ecological Landscape Monitoring Using Repeat Photography

南迦帕尔巴特地区近期土地覆盖和土地利用动态: 利用重复摄影监测人文生态景观变化

Marcus Nüsser

摘　　要

本文报道了在南迦巴瓦地区景观动态的实例。根据重复摄影，突出的是得出了景观变化和土地利用格局的变化。在 1934 年和 1937 年，两支德国考察队在这一地区进行科学研究，他们的工作成就是两幅著名的图件(1:50,000), 即展示高山地块的地貌图(Finsterwalder, 1938)和植被图（Troll，1939）。相对而言，很少有人了解它们考察中所拍摄的丰富的照片资料。作者在近期完成的该区域的野外工作中（1992—1995），尽可能地从与过去相同的视角和地点重拍一些照片，它们分别用于构画过去 60 年中人文景观变化。在资源利用和景观动态的人类生态分析的背景中，目视解译这些照片需要这样一个视角，它考虑到社会经济和历史的因素，来更好地强调近来土地覆盖变化和土地利用系统发展的驱动力。

Abstract

This article presents examples of current landscape dynamics in the Nanga Parbat region (north-west Himalayas). Based on repeat photography, emphasis will be laid on landscape changes and the development of land use patterns. In the years 1934 and 1937, two German expeditions conducted scien-

tific research in this area. Their work resulted in two well-known maps (1 : 50 000) showing the topography (FINSTERWALDER, 1938) and vegetation (TROLL, 1939) of this high mountain massif. Less known are the extensive photographic collections of these expeditions. Recent fieldwork carried out by the author in the Nanga Parbat area (1992-1995) rendered it possible to repeat some of these photographs from viewpoints identical to the earlier ones, which in turn serve to illustrate cultural landscape changes over the last sixty years. Within the context of a human-ecological analysis of resource utilisation and landscape dynamics, visual interpretations of repeat photography require a research perspective which takes into account specific socio-economic as well as historical factors for an improved understanding of the driving forces behind recent land cover changes and the development of land use systems.

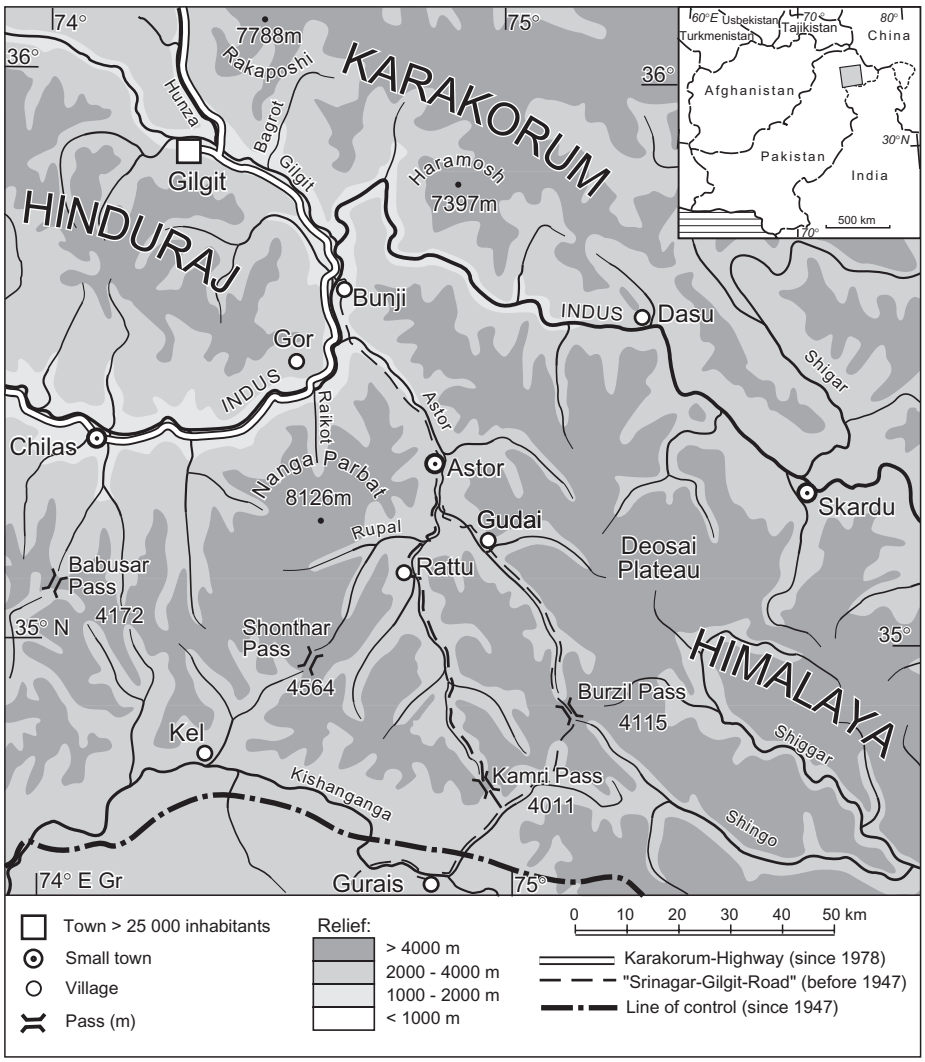
1 Introduction and objectives

Detection of land cover changes by the multitemporal interpretation of remotely sensed as well as terrestrial data has gained more and more importance during the past ten years. Like aerial photographs and satellite imagery, repeat photography can serve as a basis to establish a system for monitoring land use patterns and for detailed assessments of landscape changes. Especially in the context of uncertainty concerning the extent of recent landscape dynamics in the Himalayas (IVES & MESSERLI, 1989), replicates of historical photographs might help to cope with the problem of different interpretations of vague terms like landscape degradation and sustainability.

Using this method in the Khumbu Himal (Mt. Everest) with photographs from 1962 and 1984, BYERS (1987: 78-79) detects a relatively unchanged forest cover but a strong degradation of *Juniperus* thickets. IVES & MESSERLI (1989: 56-59) published photographs from Yunnan in 1928 and 1985. A visual comparison of these photographs shows no significant decline of forest cover over the 57-year interim. By using photographs from the late 1970s and from 1986, IVES (1987: 82-85) documents new cultivated terraces, which stabilise a landslide area in the Middle Mountains of Nepal. Comparing stereo-photographs of the German Karakorum expedition of 1959 with replicates from 1992, SPOHNER (1993) presents a detailed assessment of land use changes in two test areas of Hunza. WINIGER (1996) analyses the methodical aspects and shortcomings of repeat photography in a generalised context of landscape dynamics and high mountain research.

For the Nanga Parbat region, a comprehensive collection of historical landscape photographs taken there by members of the German Himalaya expeditions of 1934 and 1937 forms a valuable data-base for comparative studies. The metric photographs taken by FINSTERWALDER and RAECHL in 1934 as well as TROLL`s photographs from 1937 are of particular importance in this

Figure 1: Map of Nanga Parbat Region



context. Whereas the metric photographs were mostly taken from exposed viewpoints (ridges, rock spurs) in order to obtain panoramic views for the topographical mapping survey, most of the photographs by TROLL show aspects of vegetation, land use and settlement patterns. During fieldwork in the Nanga Parbat area, working on the altitudinal zonation of vegetation and pastoral resource utilisation, it was possible to re-locate selected viewpoints in order to produce a set of replicates. This bi-temporal photographic material allows a documentation of large-scale landscape changes over the last sixty

years. It serves as a basis for a qualitative human-ecological monitoring of the landscape and helps to assess temporal aspects of resource utilisation and vegetation. In order to further quantify the changes, SPOHNER and WINIGER carry out a comparative interpretation of terrestrial stereo-photographs taken by the German Himalayan expedition 1934 and the corresponding replicates from the 1990s (SPOHNER, in prep.).

2 Documentation of recent landscape dynamics using repeat photography

As part of the NW-Himalaya, Nanga Parbat towers more than 7000 m above the colline belt of the Indus river (figure 1). The extreme relief energy results in a distinct altitudinal zonation of vegetation (TROLL, 1939; NÜSSER, 1998) and land use systems (TROLL, 1973; CLEMENS & NÜSSER, 1994, 1997; NÜSSER & CLEMENS, 1996a; 1996b). The following examples of repeat photography put emphasis on some aspects of recent landscape and land use dynamics in this high mountain region.

The first pair of photographs (figures 2 & 3) show the village Dabote (2.440 m a.s.l.) in the Gor-Region, with the surrounding forests preponderantly exposed to the south-east. The lower slopes are covered with dry forests, dominated by *Quercus baloot* and *Pinus gerardiana;* in the upper part as well as in a small gorge, one can find temperate coniferous forests of the montane belt with *Pinus wallichiana* and *Picea smithiana* (TROLL, 1939; SCHICKHOFF, 1996). Apparently, only a slight change in the cover of evergreen oaks in the vicinity of the village has taken place over the 58 years. Thanks to traditional rules and regulations, such as the ban on forest pasturing as well as the loping of branches and leaves for fodder before mid-November, the *Quercus baloot*-forests have become an example of sustainable resource utilisation (NÜSSER, 1998). The photographic perspective, however, does not afford any assessment of the changes in high altitude forests.

The second bitemporal pair of photographs (figures 4 & 5) show a part of the Mushkin Forest and the slopes on the opposite side of Astor Valley. This area, with the largest high altitude forests in the Nanga Parbat region (DUTHIE, 1893: 12: "...most interesting bits of botanical ground"; see also SINGH, 1917: 6; DREW, 1875: 404) is marked by striking contrasts between the coniferous forests with *Pinus wallichiana, Picea smithiana* and *Abies pindrow* on northern aspects, and the slopes, covered with *Artemisia brevifolia* dwarf scrubs and open *Juniperus excelsa* forests on southern aspects. The visual comparison reveals strong pressure due to over-utilisation on the submontane forests in the vicinity of permanent settlements, and as a result of cutting, the lower timber line has moved around 150 m further upwards. In the montane forests, no significant change can be detected from the photographs; even the clearings inside the forest seem to be relatively unchanged.

SCHICKHOFF (1996: figures 2, 3) arrived at similar results for the ecological situation in the upper Mushkin Forest, based on forest ecological analyses. Our own observations, however, showed locally high cutting rates also in the upper Mushkin Forest.

The bitemporal comparison (figures 6 & 7) shows lower Rupal Valley with the village of Churit (2.733 m) and other settlements on different morainic terraces taken from 3.834 m a.s.l. On both sides of the Rupal river, this pair of photographs confirms the expansion of settlements through their dispersion and scattering as well as the extension of irrigated fields; however, one can not detect any extension of fruit trees. The sparsely distributed *Juniperus excelsa* thickets and trees on the slopes facing southwards, detectable on the photograph from 1934 as easily distinguishable dark spots near the settlements, are one important firewood. Owing to the relatively slighter snow cover and its earlier melting time on these southern slopes, they are used for collecting firewood between winter and spring (CLEMENS & NÜSSER, 1997: figure 4).

This last pair of photographs (figures 8 & 9) show the scree-covered Raikot glacier with the surrounding vegetation, taken from Fairy Meadows (3.303 m). Between 1934 and 1994 the position of the glacier tongue has moved around 50 m further up. Over the 60-year interim, one can detect a progressive succession of hygrophilous *Salix sericocarpa* and *Myricaria germanica* bushes along the glacio-fluvial stream. The lateral moraine shows a significant expansion of coniferous forest, proving a high potential-reproduction rate. The fence in the right corner still separates the summer settlement with cultivation from the summer pasture settlement, both lying on the same glacial terrace. This proves the persistence of a cultural geographical boundary.

3 Conclusion

In conclusion, the documentation of landscape dynamics based on the presented examples, shows that changes within the last decades have not reached an extent, which can be described by generalising terms like environmental deterioration or ecological disaster. Until the present day, the development of the cultural landscape in the Nanga Parbat region has been characterised by a land use system which is, on the one hand, highly adapted to natural resource potentials, but, on the other, it also reveals an increasing pressure on the forest resources. In particular, the relatively easily accessible forest stands in the vicinity of the settlements and near the lower timber line have been seriously depleted due to uncontrolled felling and intensive forest pasturing.

Over a period of sixty years, the development of forests shows a remarkable variability in different altitudinal zones and valleys. Generally, the montane

Figure 2: Forests of Gor **Photo: C. TROLL, 21.5.1937**

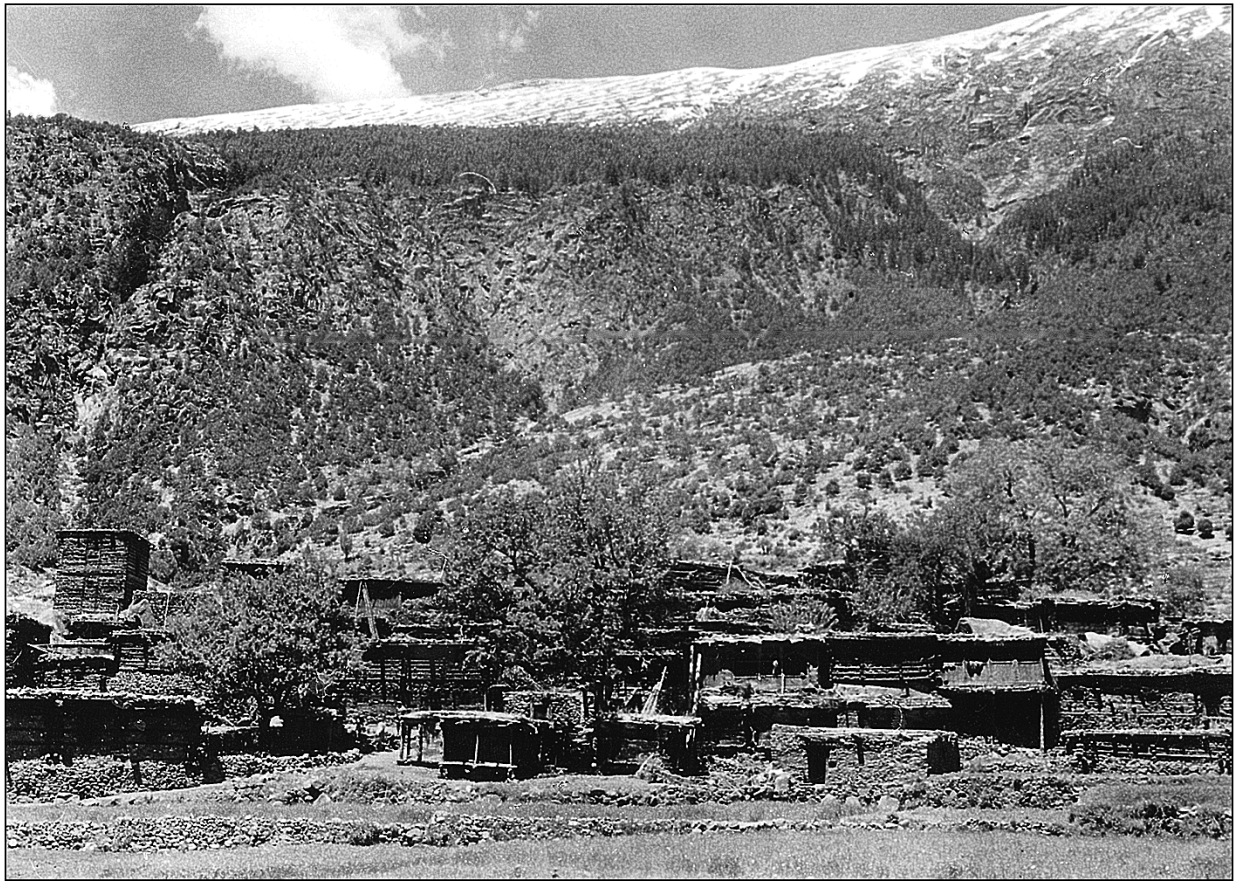


Figure 3: Forests of Gor **Photo: M. NÜSSER, 4.9.1995**

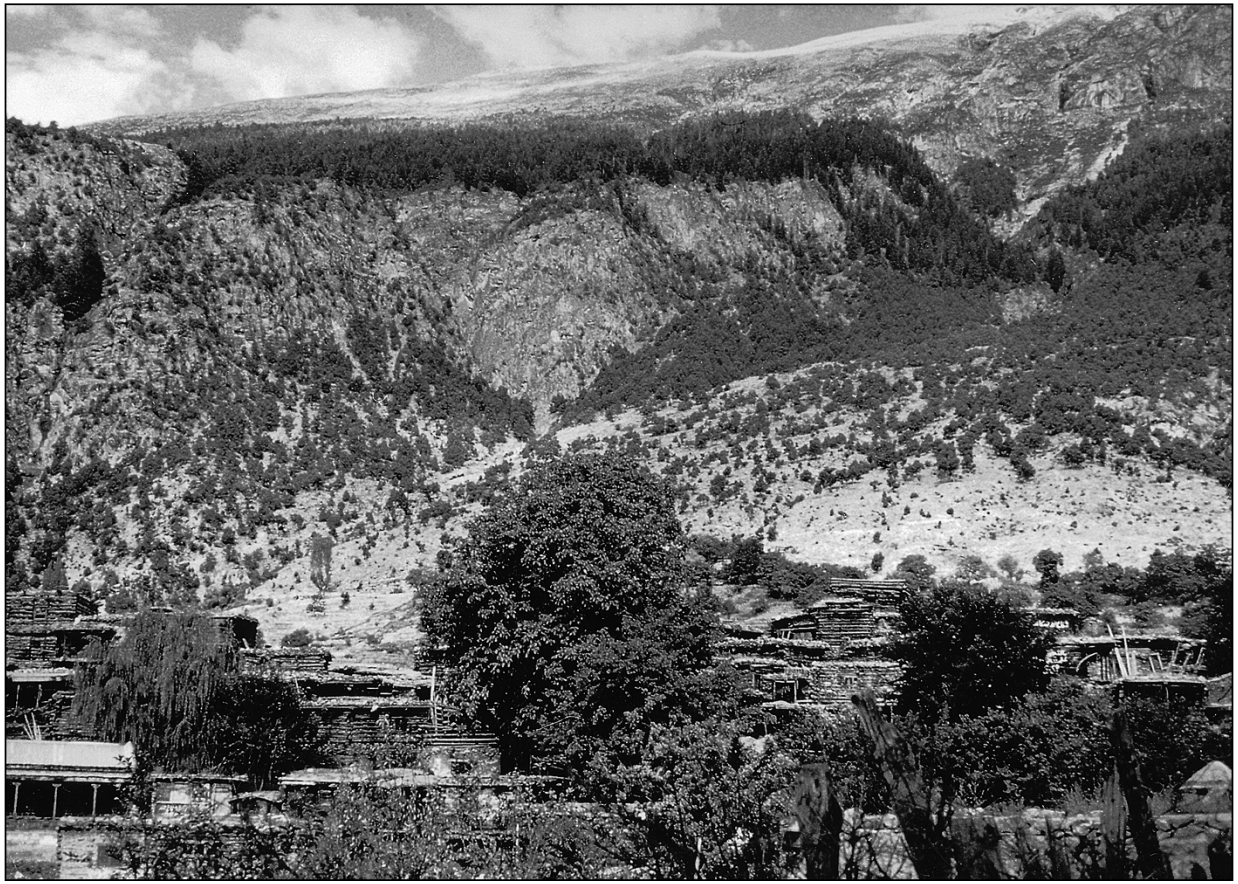


Figure 4: Mushkin Forest **Photo: C. TROLL, 14.5.1937**

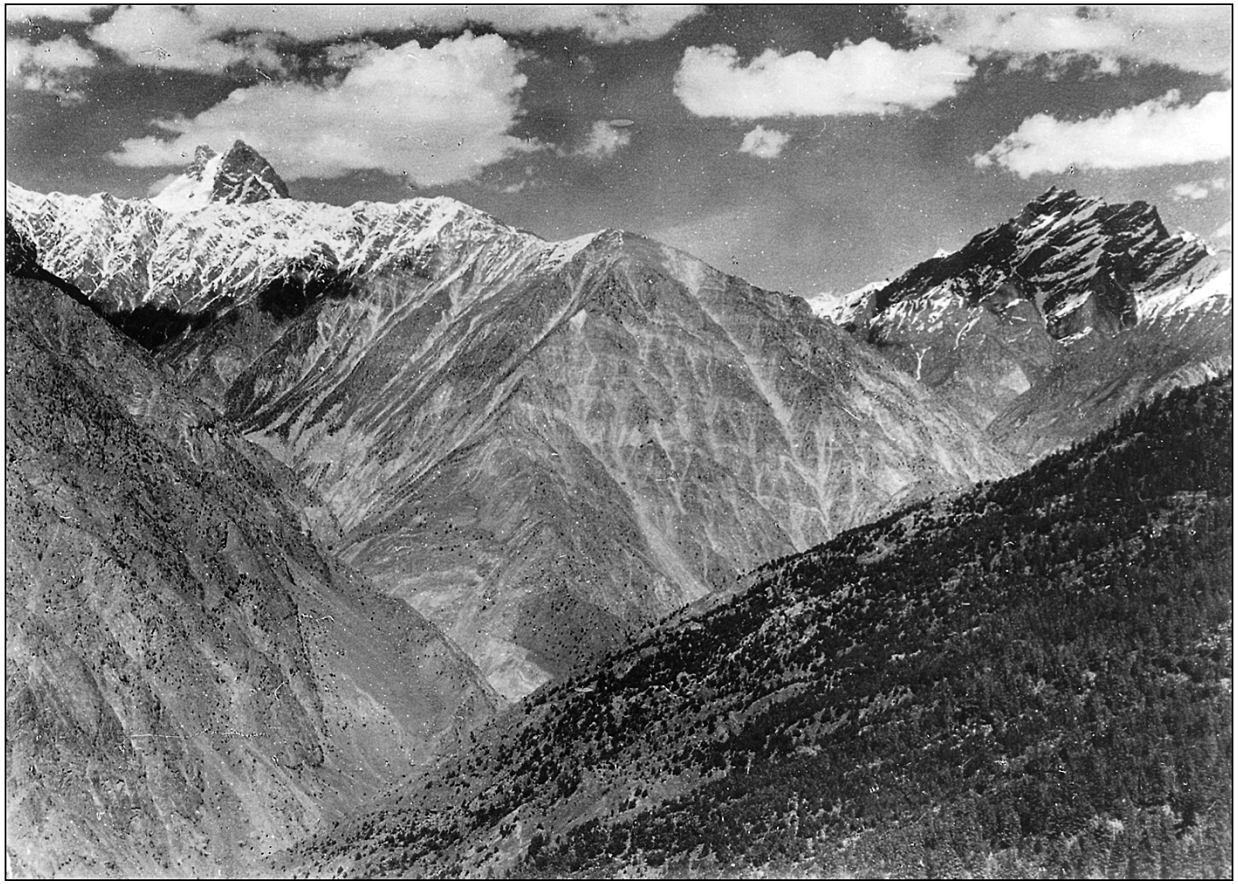


Figure 5: Mushkin Forest **Photo: M. NÜSSER, 6.9.1995**

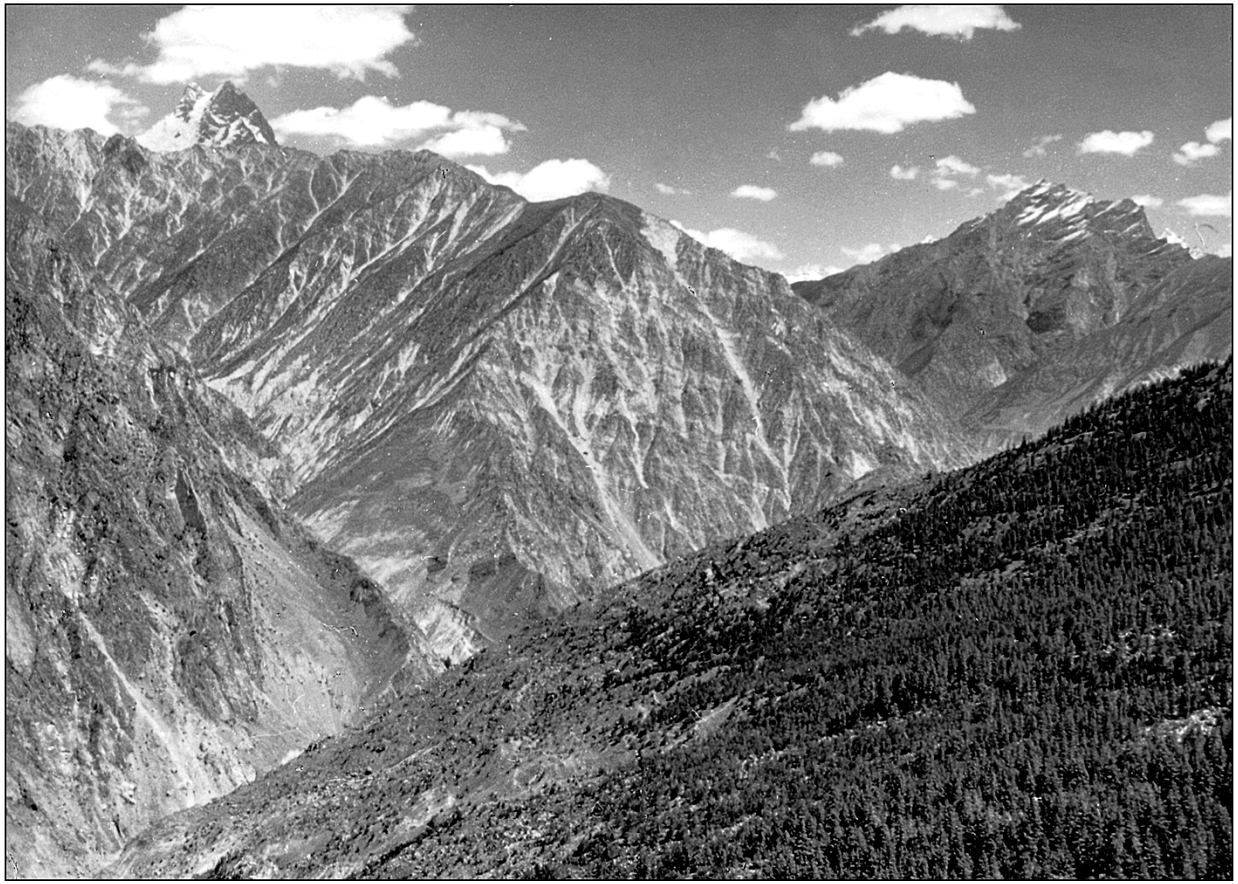


Figure 6: Lower Rupal Valley with village Churit **Photo: R. FINSTERWALDER, 21.6.1934**

Figure 7: Lower Rupal Valley with village Churit **Photo: M. NÜSSER, 22.7.1994**

Figure 8: Raikot Glacier **Photo: R. FINSTERWALDER, 16.5.1934**

Figure 9: Raikot Glacier **Photo: M. NÜSSER, 2.6.1994**

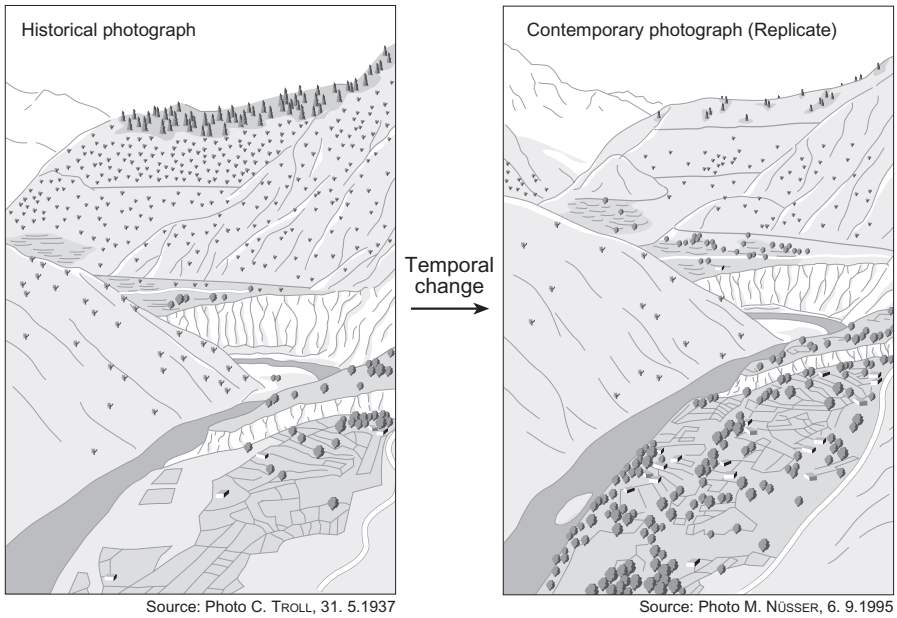
coniferous forests are locally characterised by a gradual decline though in places the changes are certainly drastic owing to local over-exploitation. On the other hand, one can observe an extension of coniferous forests by progressive succession in the vicinity of retreating glaciers. The submontane forests near the permanent settlements are degraded, in some cases totally destroyed. In comparison, the situation of submontane oak forests in Gor looks more positive. Rules and regulations, controlled by institutional arrangements have succeeded in preserving these woodlands until the present day.

Due to the general population growth, the development of the cultural landscape is characterised by the expansion of settlements and cultivated areas in all valleys. In most examples, the limit of this expansion, dependent upon the availability of water has not yet been reached. Only the area of Gor, lacking as it does a glaciated upper valley head, and therefore solely dependent on melted snow, the shortage of water has prevented any further expansion of the irrigated area. On the local scale, the intensified irrigation by new water channels has led to an increase of hygrophilous vegetation along the channels and below the cultivated terraces. In different examples, one can also detect the enlargement of settlements as well as the extension of the road network.

The examples from the Nanga Parbat area prove that visual interpretation of repeat photography can serve as a basis for a qualitative assessment of landscape dynamics. This method of change detection, however, stipulates a comprehensive consideration of various influences resulting from difficulties in data collection. Such difficulties are accuracy of viewpoint, the congruence of the historical photograph and the replicate, as well as problems of visibility caused by shadows, clouds and snow cover. Because of geometrical problems such as projective distortions, there are significant difficulties in deriving absolute area measurements of irrigated fields or vegetation formations from non-metric photographs. In many cases, estimations of forest densities and smaller vegetation units are difficult or impossible because of inappropriate perspectives. Furthermore, one has to consider seasonal differences in the phenology of the crops and vegetation in order to assess changes of cultivated areas and formations (figure 10). Because of all these limitations, an assessment of the density of forest covers cannot be based on repeat photography exclusively (see examples in NÜSSER & SCHICKHOFF, 1996: 98ff.).

The assessment of landscape dynamics requires a research perspective, which takes into account socio-economic developments as well as historical processes. In the light of vague definitions of terms such as carrying capacity and sustainable resource utilisation, repeat photography provides a valuable tool in assessing recent changes in natural and human-ecological spheres. Like ground truth verification in remote sensing, the comparison of bitemporal photographs and the understanding of contemporary landscape dynamics strongly depends on the integration of additional fieldwork and mapping. If

Figure 10: Assessment of recent landscape changes using repeat photography



Visual interpretation of bi-temporal photographs

Procedure

Identification
↓ of objects
Classification
↓
Bi-temporal comparison
↓
Change detection

Problems and limitations

- Choice of site
  (identical viewpoints)
- Visibility, lighting
  (shadowing effects, clouds, snow cover)
- Geometrical differences
  (projective distortions)
- Seasonal differences
  (phenology)

Interpretation of results in a human-ecological context

- assessment of natural resources
  (potentials and limitations, carrying capacity)
- integration of the socio-economic and historical context
  (population growth, rights of resource utilisation, institutional arrangements)

Draft: M. Nüsser

Cartography: H. Kieslinger

these conditions are fulfilled, bitemporal and multitemporal comparisons of the terrestrial photographs can serve as a fundamental basis in monitoring vegetation and land use patterns.

Acknowledgements

As a member of the interdisciplinary research project "Culture Area Karakorum", the author is first of all indebted to the German Research Council (DFG) and the project's scientific co-ordinators Prof. I. Stellrecht (Tübingen), Prof. E. Ehlers (Bonn) and Prof. M. Winiger (Bonn). Botanical names correspond to the taxonomy drawn out by Dr. W. B. Dickoré (Göttingen) within the framework of the "Flora Karakorumensis" Project. For the access to, and the permission to reproduce the historical photographs, the author is indebted to Prof. Dr. Rüd. Finsterwalder (München) and Dr. I. Hönsch (Leipzig). Usama W. Azhar (Islamabad/Bonn) proof-read the translation.

References

BYERS, A. (1987): An Assessment of Landscape Change in the Khumbu Region of Nepal Using Repeat Photography. Mountain Research and Development 7: 77-81.

CLEMENS, J. & M. NÜSSER (1994): Mobile Tierhaltung und Naturraumausstattung im Rupal-Tal des Nanga Parbat (Nordwesthimalaja): Almwirtschaft und sozioökonomischer Wandel. Petermanns Geographische Mitteilungen 138: 371-387.

CLEMENS, J. & M. NÜSSER (1997): Resource Management in Rupal Valley, northern Pakistan: The Utilisation of Forests and Pastures in the Nanga Parbat Area. In: STELLRECHT, I. & M. WINIGER (eds.): Perspectives on History and Change in the Karakorum, Hindukush and Himalaya. Köln: 235-263 (= Culture Area Karakorum, Scientific Studies 3).

DREW, F. (1875): The Jummoo and Kashmir Territories. A Geographical Account. London [Reprint Karachi 1980].

DUTHIE, J. F (1893): Report on a Botanical Tour in Kashmir, 1892. Records of the Botanical Survey of India 1 (1): 1-18.

FINSTERWALDER, R. (1938): Die geodätischen, gletscherkundlichen und geographischen Ergebnisse der deutschen Himalaja Expedition 1934 zum Nanga Parbat. Berlin (= Deutsche Forschung. Schriften der Deutschen Forschungsgemeinschaft, N.F. 2).

IVES, J. D. (1987): Repeat Photography of Debris Flows and Agricultural Terraces in the Middle Mountains, Nepal. Mountain Research and Development 7: 82-86.

IVES, J. D. & B. MESSERLI (1989): The Himalayan Dilemma. Reconciling Development and Conservation. London.

NÜSSER, M. (1998): Nanga Parbat (NW-Himalaya): Naturräumliche Ressourcenausstattung und humanökologische Gefügemuster der Landnutzung. Bonner Geographische Abhandlungen 97.

NÜSSER, M. & J. CLEMENS (1996a): Impacts on Mixed Mountain Agriculture in Rupal Valley, Nanga Parbat, northern Pakistan. Mountain Research and Development 16: 117-133.

NÜSSER, M. & J. CLEMENS (1996b): Landnutzungsmuster am Nanga Parbat: Genese und rezente Entwicklungsdynamik. In: KICK, W. (ed.): Forschung am Nanga Parbat. Geschichte und Ergebnisse. Beiträge und Materialien zur Regionalen Geographie 8: 157-176.

NÜSSER, M. & U. SCHICKHOFF (1996): Traditionelle Methoden der Vegetationsgeographie im Wandel: Potentiale und Limitierungen der digitalen Verarbeitung vegetationsbezogener Datensätze. Die Erde 127: 93-112.

SCHICKHOFF, U. (1996): Die Wälder der Nanga-Parbat-Region: Standortsbedingungen, Nutzung, Degradation. In: KICK, W. (ed.): Forschung am Nanga Parbat. Geschichte und Ergebnisse. Beiträge und Materialien zur Regionalen Geographie 8: 177-189.

SINGH, T. (1917): Assessment Report of the Gilgit Tahsil. Lahore.

SPOHNER, R. (1993): Auswertung terrestrischer Photographien zur Quantifizierung von Landschaftsveränderungen. Exemplarische Auswertung im Hunza-Tal (Karakorum) 1959-1992. Master-Thesis, Institute of Geography, University of Bonn (unpubl.).

SPOHNER, R. (in prep.): Rezente Landschaftsveränderungen im NW-Karakorum und NW-Himalaya. Integrative Methode aus Photogrammetrie, Satellitenfernerkundung und GIS. (Bonn, forthcoming PhD-Thesis).

TROLL, C. (1939): Das Pflanzenkleid des Nanga Parbat. Begleitworte zur Vegetationskarte der Nanga Parbat-Gruppe (Nordwest-Himalaja) 1:50 000. Wissenschaftliche Veröffentlichungen des Deutschen Museums für Länderkunde zu Leipzig, N.F. 7: 149-193.

TROLL, C. (1973): Die Höhenstaffelung des Bauern- und Wanderhirtentums im Nanga Parbat-Gebiet (Indus-Himalaya). In: RATHJENS, C., C. TROLL & H. UHLIG (eds.): Vergleichende Kulturgeographie der Hochgebirge des südlichen Asien. Wiesbaden: 43-48 (= Erdwissenschaftliche Forschung 5).

WINIGER, M. (1996): Karakorum im Wandel - Ein methodischer Beitrag zur Erfassung der Landschaftsdynamik in Hochgebirgen. In: HURNI, H. et al. (eds.): Umwelt Mensch Gebirge. Beiträge zur Dynamik von Natur- und Lebensraum. Bern: 59-74 (= Jahrbuch der Geographischen Gesellschaft Bern 59).