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Understanding cultural landscape transformation: a re-photographic survey in Chitral, eastern Hindukush, Pakistan

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Abstract

Studies of contemporary land-cover change require an integrated approach because changes in cover and environmental conditions are primarily caused by land uses, which, in turn are governed by human driving forces in a specific socio-economic and cultural context. Therefore, a research perspective which bridges the gap between the more specialized approaches of natural and social sciences is required. The present study, investigates cultural landscape transformation in the high mountain oases of Chitral, lying in the eastern Hindukush. Comparisons of historical photographs and replicates serve to demonstrate change and persistence of cultural landscape structures. The focus is on the irrigated fields of individual villages and shortened in time scale to the last 30 years. Due to the general population growth, the development of the cultural landscape is characterized by recent village enlargements and corresponding extensions of cultivated areas while the individual field sizes decrease. Intensified irrigation of the cultivated terraces has led to a significant increase in hygrophilous trees and thickets along the water channels. The regional center of Chitral Town is characterized by a higher building density and expansion of urban structures. The results show that repeat photography can serve as a basis for monitoring contemporary landscape transformation.

Keywords: Land-cover change; Cultural landscapes; Land-use patterns; Photo interpretation; Mountains

1. Introduction

Regional land-use systems are cumulatively transforming land cover at various scales and alter the environmental conditions of ecosystems at an accelerating pace. The dimension of corresponding landscape transformations from the local to the global level, lead to the hypothesis of a transitional stage from nature-dominated to human-dominated environmental changes in the 20th century (Messerli et al., 2000) or to the ''human domination of Earth's ecosystems'' (Vitousek et al., 1997). To meet the challenge of understanding the complexity of landscape transformation, it is necessary to focus on the interactions between landscapes and the human driving forces which have shaped and changed them (Naveh, 1995; Antrop, 1998; Ehlers, 2000). Therefore, the analysis of this issue needs to consider the linkages between patterns and processes which are within the domain of both the natural and social sciences. Regarding the ongoing process of landscape degradation in many landscapes and ecosystems, Naveh (2000) postulates a broader and more distinct problem-solving oriented approach in landscape research. The *total human ecosystem* (Naveh and Liebermann, 1994) provides

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an overarching framework for a holistic and transdisciplinary conception of landscape ecology.

The issues of land-use and land-cover change denote topics that have historically been separate in research tradition and disciplinary conventions. Whereas, the issue of land-use change (shift to a different type of use or intensification of an existing one) has primarily been a concern of social scientists, land-cover change (modification or conversion of the physical environment) has basically been addressed by natural scientists (Turner and Meyer, 1994; Turner et al., 1994; Geist, 1999). Cultural landscape transformation represents the point of intersection between the core concerns of the natural and social sciences, involved in landscape research. Nassauer (1995) emphasizes the necessity of binding cultural insights with ecological knowledge, as the intrinsic reciprocal relationship between culture and landscape structures is evident. Consequently, bridging human and natural sciences is of crucial importance for an in-depth understanding of cultural landscapes between continuity and change. As contemporary landscape transformation is diverse in character and scope, the detection of change and persistence must be based on regional case studies. Such case studies are required to provide the spatial and temporal resolution necessary to identify and account for major variations in the frequency and magnitude of cultural landscape transformation. Apparently, the analysis of this issue needs to integrate specific aspects of the regional socio-economic context.

Integrated approaches, based on a holistic research perspective that explicitly includes humans or, more specifically, social systems are also postulated for high mountain research (Forsyth, 1998; Nüsser, 1998). In these marginal belts of human habitation, environmental conditions and related potentials, limitations, and ecological risks of natural resource utilization are intimately linked. Especially in developing countries, regional livelihood strategies primarily depend on subsistence farming, animal husbandry, and forest utilization. Therefore, a problem oriented analysis of landscape transformation needs to encompass potentials, limitations and risks of natural resource utilization together with socio-economic and historical aspects of land-use systems. The most prominent example of the *Himalayan dilemma* (Ives and Messerli, 1989) provides a reconsideration of the environmental crisis and population growth in High Asia and challenges simplified views of landscape degradation. The study reveals the uncertainties about the extent of contemporary landscape changes and the role of local mountain communities. Frequently addressed questions are: whether or not population pressure leads to over-exploitation and subsequent landscape degradation; whether or not the indigenous strategies of local farmers are flexible enough to cope with new challenges and conditions posed by exogenous influences; and whether or not changes of the traditional subsistence economy as a consequence of the modernization process are reflected in landscape transformations.

This study presents an assessment of cultural landscape transformation in Chitral, lying in the eastern Hindukush. The main research objective is twofold: (1) to detect contemporary landscape transformation based on a qualitative evaluation of repeat photography; and (2) to explain change and persistence of land-cover in the context of an integrated analysis of natural resource utilization and land-use systems. Using this approach in the north-western Himalayas (Nanga Parbat area), Nüsser (2000) demonstrates that the cultivated areas and settlements have expanded and the forests in the vicinity of the villages have been seriously degraded owing to local over-exploitation. Chitral is located at a distance of approximately 250 km to the west of Nanga Parbat. Both areas are located in northern Pakistan, but offer heterogeneous environmental settings and different grades of accessibility. Compared with the north-western Himalayas, which are characterized by sub-humid conditions in the montane belt, the eastern Hindukush is generally characterized by a more arid climatic regime. Beside the ecological differences between the two regions, Chitral is less accessible than the Nanga Parbat area. It has yet to be seen whether or not such differences account for major variations in cultural landscape transformation.

2. Study area: Chitral

The Chitral district (ca. 35–37°N, 71–74°E) constitutes the northern most district of Pakistan's North-West Frontier Province (N.W.F.P.) and borders Afghanistan to the north and to the west (Fig. 1). Chitral constitutes the drainage system to the east of

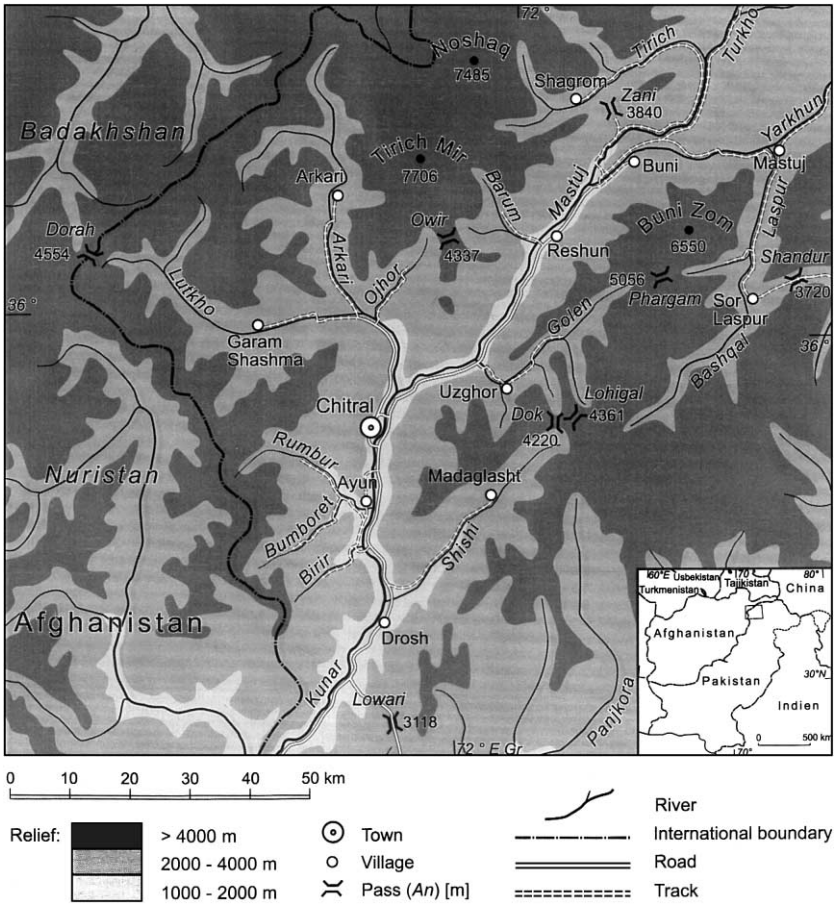

Fig. 1. The location of Chitral valley in northern Pakistan.

the main Hindukush range. The main valley runs down from 2800 m in the northeast to 2000 m in the southwest over a distance of approximately 300 km. On both sides, the main valley is flanked by glaciated mountain ranges, with altitudes between 5500 and 7700 m. The valley floors display arid conditions and the vegetation is characterized by open dwarf scrub communities and sharply delimited groundwater-dependent wood and shrublands along tributary streams and irrigation channels.

Generally, the land-use system in Chitral can be characterized as an integrated agro-pastoral economy, relying on a combination of irrigated cultivation and animal husbandry. Within this *mixed mountain agriculture* (Rhoades and Thompson, 1975) crop cultivation and pasturing are interdependently connected and extend across different altitudinal belts (Nüsser, 1999). Mountain communities subsist on this traditional production strategy to a considerable extent by increasing the variety of potential resources and by decreasing the threat of failure of any of those resources due to natural hazards. Gravity induced mass movements, such as landslides, rockfalls, and flash floods pose a recurrent threat for settlements, irrigation channels, and cultivated land. Climatic events, such as torrential rainfall, heavy snowfall before harvests, and variations in the length of the vegetation growth period, further determine the limitations and risks of the agro-pastoral economy.

As crop cultivation in an arid mountain environment like Chitral is almost entirely dependent on the availability of glacial and snow melt water for artificial

irrigation, the settlement oases with agriculture are located along the streams and especially on the alluvial fans of tributary valleys. Gravity-fed channels and a highly sophisticated irrigation network form the basis of crop cultivation (Kreutzmann, 1990). At different localities and altitudes wheat (up to ca. 3300 m), maize (up to ca. 2900 m), rice (up to ca. 2300 m), and barley (up to ca. 3500 m) comprise the most common crops. Double cropping is possible in the main valley between Drosh and Buni (Fig. 1) and its upper limit can be noted at an altitude of approximately 2500 m (Haserodt, 1989). Crop residues, wild hay, and fodder trees (*Salix* spp., *Populus* spp.) form the major source for the livestock's winter supplies, supplemented by the cultivation of lucerne (*Medicago sativa*, *M. X varia*). Small scale cultivation of fruit trees, especially mulberries (*Morus alba*), apricots (*Prunus armenica*), and walnuts (*Juglans regia*) is limited to altitudes below approximately 2800 m (Haserodt, 1989).

For the entire Chitral district, Kreutzmann (1996, p. 268) calculates an average annual population growth rate of 2.3% for the time period between 1951 and 1981, which is relatively high given the limited resources available. This demographic development raises questions of sustainable land-use and environmental degradation. The peripheral region of Chitral is characterized by rudimentary accessibility as the only road to Peshawar (ca. 400 km to the south) over Lowari Pass (3118 m) is impassable for 7 months because of snow conditions. The inaccessibility for motorized transports between November and May is problematic, as the food security of a growing mountain population strongly depends on additional supplies from the lowland economic centers of Pakistan. The remoteness of Chitral also accounts for the fact that the region has largely been neglected as a research area.

3. Methods

3.1. Repeat photography

In the context of interdisciplinary perspectives of aerial photo interpretation in landscape research, Troll (1939) coined the phrase *landscape ecology* and he also mentioned the possibility to detect cultural landscape changes using time series of aerial photographs. Change detection by multitemporal interpretation of satellite data has increasingly gained importance in a wide range of disciplines, focusing on landscape and urban research (Avery and Berlin, 1992; Lillesand and Kiefer, 1994). As with monitoring approaches using remote sensing data, a comparative interpretation of matched pairs of terrestrial photographs can serve

Fig. 2. Cultivated fields in Phargam valley (photo by Haserodt, 9 June 1978; taken from 3260 m, view towards east).

to assess contemporary landscape transformation (Rogers, 1982; Byers, 2000).

Repeat photography is the practice of finding the location of an earlier photograph, reoccupying the original camera position, and taking a new photograph of the same scene (Rogers et al., 1984). Depending on the availability of historical landscape photographs the primary goal of re-photographic surveys is to produce a set of replicates from viewpoints identical to the earlier ones. Ideally, panoramic images taken from exposed viewpoints form a suitable material for replication. The retrospective approach is based upon the fact that the comparative interpretation between the original photographs and the replicates can serve as a basis for detailed assessments of change and/or persistence of landscape structures (vegetation, land-use patterns, settlements). Thus, this method is appropriate to provide a database for interdisciplinary analyses of land-use and land-cover changes.

The approach has been widely used by geographers and ecologists in various regions, e.g. in the US (Veblen and Lorenz, 1991; Webb, 1996) and in South Africa (Hoffmann and Cowling, 1990). Until now, very little repeat photographic studies have been undertaken in the mountains of High Asia, with the notable exceptions of Byers (1987) in the Khumbu Himal (Nepal) and Ives (1987) in the middle mountains of Nepal. A comprehensive collection of historical landscape photographs from Chitral, taken by the geographer K. Haserodt (Berlin) in 1966 and 1978 forms a valuable database for repeat photography. Fieldwork in 1997 rendered it possible to repeat eight of these photographs focusing on the development of the cultivated areas and settlement patterns in different valleys. Based on this bitemporal photographic material and additional interviews with the local population, cultural landscape transformation over the last 20–30 years can be illustrated and discussed. The prerequisite for the selection of the presented sample has been twofold: (1) to show typical and representative examples; and (2) to cover different sub-regions of the study area.

3.2. Visual interpretation

The method of comparing matched pairs of photographs is based on visual image interpretation and qualitative evaluations of changed and unchanged elements. Visual image interpretation of photographs is a non-numerical approach starting from the perceived image characteristics (Antrop and Van Eetvelde, 2000). Basic characteristics of the image used during visual interpretation are shape, size, pattern, tone, texture, shadows, geographic or topographic site and associations between features and identified objects (Lillesand and Kiefer, 1994). The

Fig. 3. Cultivated fields in Phargam valley (photo by Nüsser, 24 June 1997; replicate).

possibility to detect heterogeneity and homogeneity of image structures determines the spatial resolution (scale) of interpretation; the availability of suitable photographic material from different times determines the time-span for monitoring change and persistence of landscape structures.

Change detection from photographs requires discernible differences between the moments of observation. Therefore, important factors for interpretation are the degree of detail in the photographs and the comparability of the material used. The basic image characteristics of the photographs perceived on hard copies and on a screen serve as a basis for the interpretation of landscape changes. In order to visualize and illustrate the results of comparative image interpretation discernible landscape features (elements, structures and patterns) have been digitized on a screen. This interpretation procedure begins with an extraction of the topographical and geomorphological landscape features (e.g. ridges, drainage patterns), followed by the documentation of changed and unchanged land-use and land-cover structures (e.g. settlement patterns, irrigated fields, forest distribution).

4. Results

4.1. Phargam

The first pair of photographs (Figs. 2 and 3) shows the village Phargam (3120 m), located on an alluvial fan south of Buni Zom (6550 m) with the Laspur valley and the village Harchin in the right background.

According to own investigations in 1997, 40 households (approximately 300 people) live in Phargam. In all aspects, the lower slopes are covered with open dwarf scrub communities on scree. The matched pair of photographs proves that the irrigated area has been further expanded between 1978 and 1997. Whereas, only the lower portion of the alluvial fan in the left mid-ground was brought under cultivation in 1978, the expansion of the cultivated area dominated by wheat, barley, hay meadows, and a few maize fields can be estimated at approximately 20%. The limit of this expansion, dependent upon the availability of melt water and topographical factors, have only been reached along the steep scree slopes in the background and along the edges of the alluvial fan. The comparative interpretation over the time-span of 19 years also shows a considerable increase in deciduous trees, mostly willows (*Salix sericocarpa*) and poplars (*Populus nigra*), as well as groundwater-dependent woodlands (*Hippophae rhamnoides* subsp. *turkestanica*, *Rosa webbiana*) along the new terraces and irrigation channels. These hygrophilous woodlands are used as a valuable fuel-resource and lopped for winter fodder. The photograph from 1978 shows a group of boys with bundles of collected dwarf scrubs (*Artemisia brevifolia, Acantholimon lycopodioides, Ephedra gerardiana*) further indicating the necessity to cope with scarce fuel-wood resources in a treeless environment. Although this is not evident in the 1997 photograph, this practice of resource utilization is still prevalent today.

4.2. Shagrom

The second bitemporal comparison (Figs. 4 and 5) shows Shagrom (2850 m), the uppermost permanently inhabited settlement in the Tirich valley, lying north of Tirich Mir (7706 m).

According to population statistics from 1996 (Agriculture Office Buni, unpublished) 57 households (between 400 and 450 people) live in this village. Change detection between 1966 and 1997 reveals the expansion of the settlement through its dispersion and scattering. Due to topographical constraints, the cultivated area has only slightly expanded on the lower terrace near the river. The individual fields within the irrigated area have become more fragmented into smaller plots because of land subdivisions through inheritance. As with the previous example of Phargam, one can detect a considerable increase in deciduous trees (*Salix* spp., *Populus nigra*, *P. pamirica*) as well as woodlands along the new terraces and irrigation channels (Fig. 6).

The combination of fieldwork results (questionnaires, mapping) and visual image interpretation allows to estimate a total woodland increase of approximately 25%. This expansion of deciduous woodlands reduces the scarcity of fuel-wood and winter fodder. The three irrigation channels on the slope in the background, detectable as rows of trees, have not changed over the observation period of 31 years. Flow channels are visible in the older photograph, suggesting relatively recent fluvial activity across the entire fan in the left foreground. However,

Fig. 4. Cultivated fields of Shagrom in Tirich valley (photo by Haserodt, 26 June 1966; taken from 3020 m, view towards northwest).

Fig. 5. Cultivated fields of Shagrom in Tirich valley (photo by Nüsser, 4 June 1997; replicate).

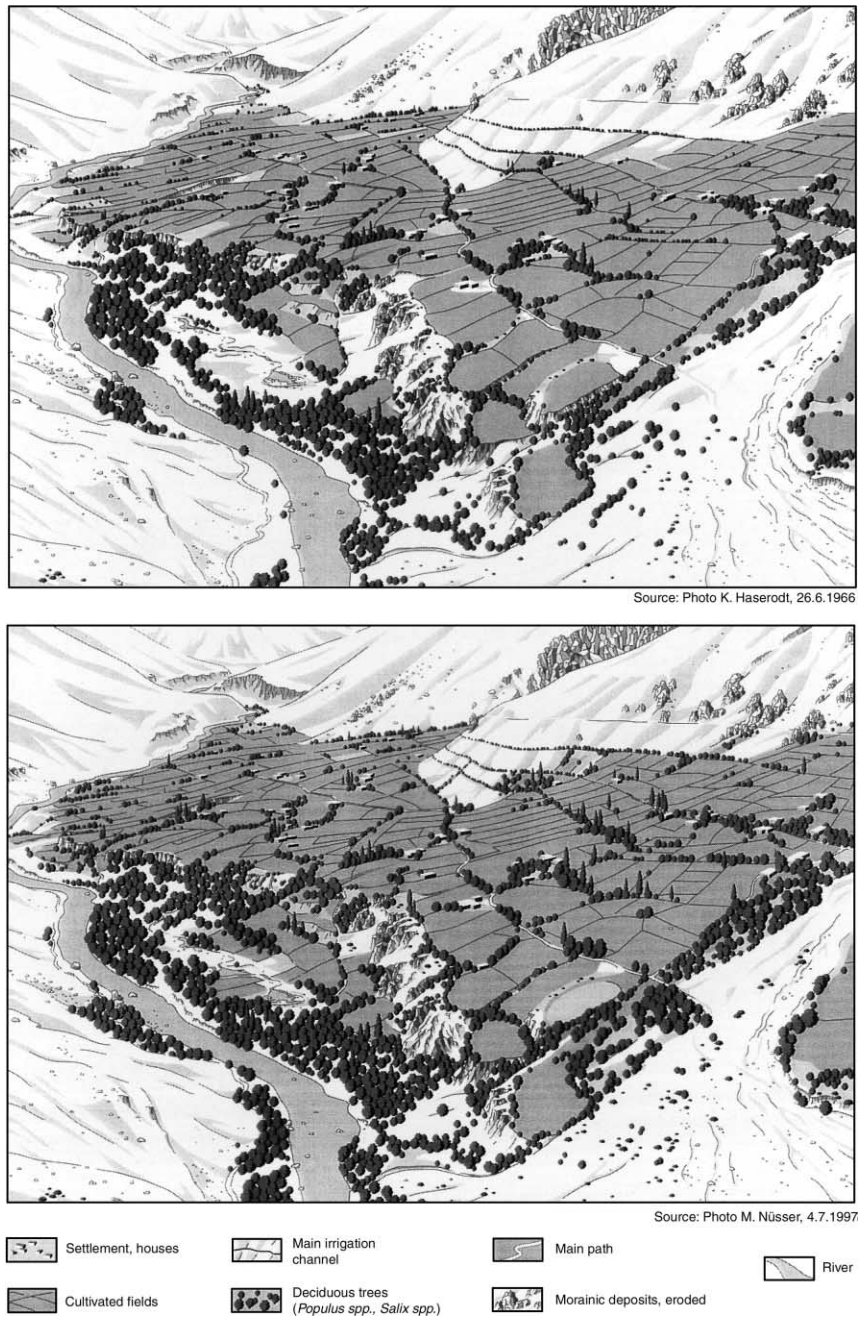

Fig. 6. Visual interpretation of cultural landscape transformation in Shagrom between 1966 and 1997.

in the 1997 photograph the extensive distribution of thickets and shrubs over much of the alluvial fan may suggest relative geomorphic stability during recent years.

4.3. Chitral Town

The third comparison shows Chitral Town (1490 m) and focuses on the development of the regional

economical and political-administrative center of the whole valley. The matched pair of photographs (Figs. 7 and 8) demonstrates that the development of the urban structures between 1978 and 1997 is characterized by a higher building density and significant expansion of the townscape.

This development reduces the open space especially in the triangular village core. The photograph of 1978 (Fig. 7) shows a homogenous linear structure of small bazaar boxes in the foreground. In 1997, this central part of the main bazaar has become more heterogeneous because of different building types and heights (Fig. 8). Some of the bigger buildings in this part are recently built hotels for foreign trekking tourists. This development indicates socio-economic changes posed by a rapid transformation process in this remote area. Most of the buildings in the background serve for administrative and military purposes. Another characteristic development of the recent urban expansion are new houses scattered all over the cultivated area in the right foreground. In contrast, the mosque and the historical fort of Chitral in the upper left town area offer developmental stability, owing to religious and cultural factors (Fig. 9).

5. Discussion

Comparative image interpretation and change detection requires a comprehensive consideration of various influences and constraints resulting from difficulties in data collection. These problems include accuracy of viewpoint, the congruence of the historical photograph and the replicate, and problems of visibility caused by shadows and clouds. In order to avoid misinterpretations in change detection, especially in cultivated areas and vegetation, seasonal differences between historical photographs and replicates must be considered. Taking into account these methodological problems, visual interpretation of terrestrial photographs of the same landscape taken many years apart provides a valuable tool to get valid information on the culturally induced landscape transformation. The approach provides the necessary resolution to identify and account for the character and scope of contemporary land-use and land-cover change and can therefore serve as a basis for a better understanding of cultural landscape transformation. However, the interpretation of variations in the frequency and magnitude of these changes strongly depends on the integration of additional information from other data sources (e.g. interviews, reviews of literature).

An integrated analysis of the irrigated mountain agriculture has to encompass aspects of agro-ecological resource potentials together with relevant aspects of the regional resource management system. Due to the general population growth in the study area, the development of the cultural landscape is characterized by recent village enlargements, corresponding extensions of irrigation networks and cultivated areas, and a significant increase of fruit and fodder trees in the village environs. In the remote irrigated oases Shagrom and Phargam, land-use change is reduced to the expansion and intensification of an existing type of utilization, and corresponding land-cover change becomes obvious by the conversion of previous dwarf scrub communities into irrigated land. The intensified irrigation has led to an increase of hygrophilous vegetation along the new water channels and below the cultivated terraces. The character and magnitude of subsequent landscape changes can be characterized as a gradual process of increasing and expanding cultural domination of the village environs.

As one example of sustainable resource utilization, the upkeep and expansion of irrigation systems indicates the functioning and stability of communal arrangements. The construction, maintenance, and repair of the irrigation network as well as the distribution of water on the individual fields have to be carried out within the village communities. Most of the main irrigation channels in Chitral run over long distances from the glaciated upper valley heads to the cultivated areas. As these channels also cross active scree slopes and talus cones, they are permanently disposed to breaches by landslides and flash floods. These mass movements often result in a disruption of the whole irrigation network and require urgent operations for repair (Kreutzmann, 1990, 2000; Israr-ud-din, 2000). In order to secure enough workforce to cope with the labor intensive demands of the irrigation system, all households of the village have to contribute to the communal labor according to a rotational plan. Irrigation groups act as institutions to organize and regulate communal labor. The expansion of the highly sophisticated irrigation system also indicates the consistency of using *traditional ecological knowledge*, which

Fig. 7. The central place Chitral Town (photo by Haserodt, 17 June 1978; taken from 1850 m, view towards east).

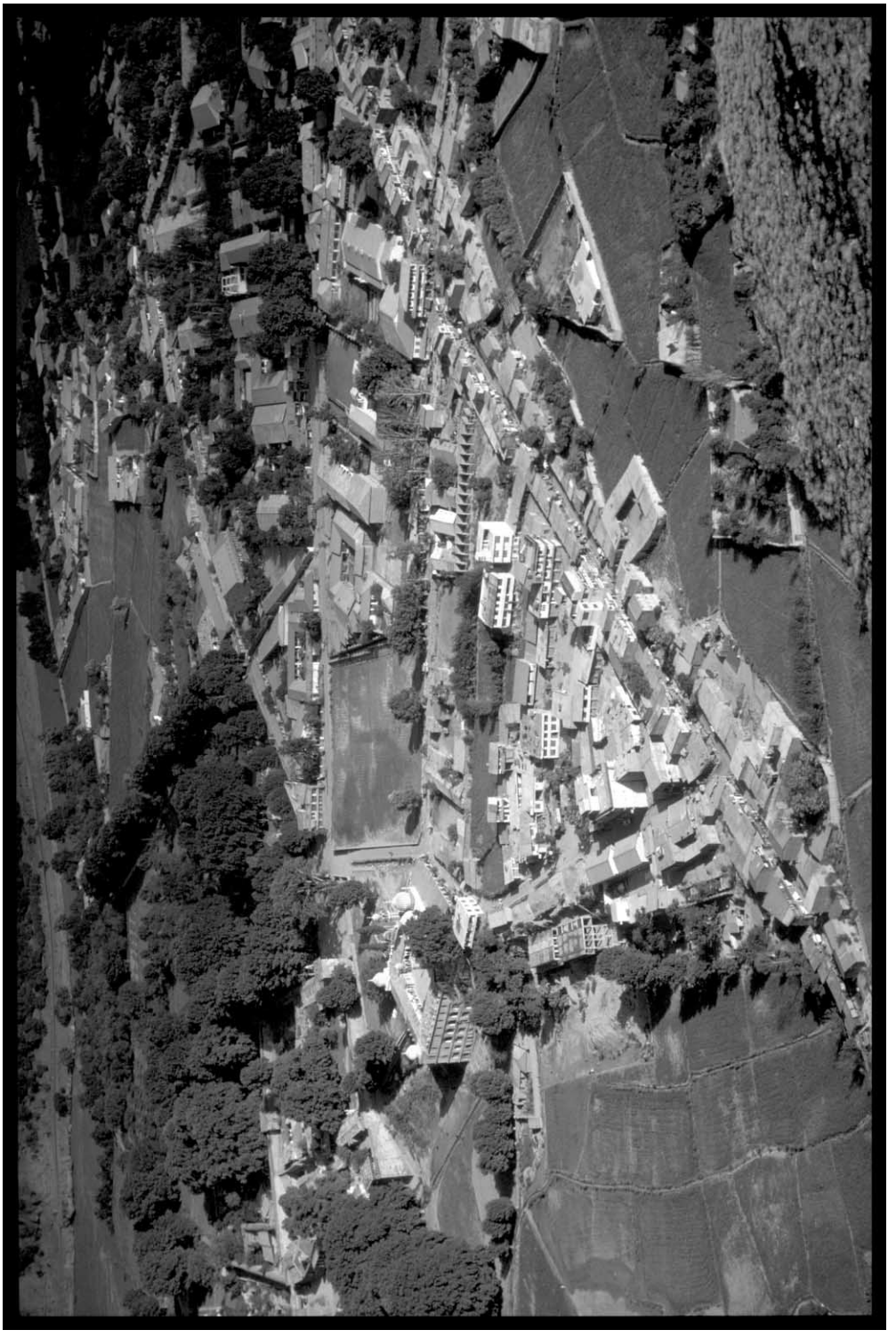

Fig. 8. The central place Chitral Town (photo by Nüsser, 31 July 1997; replicate).

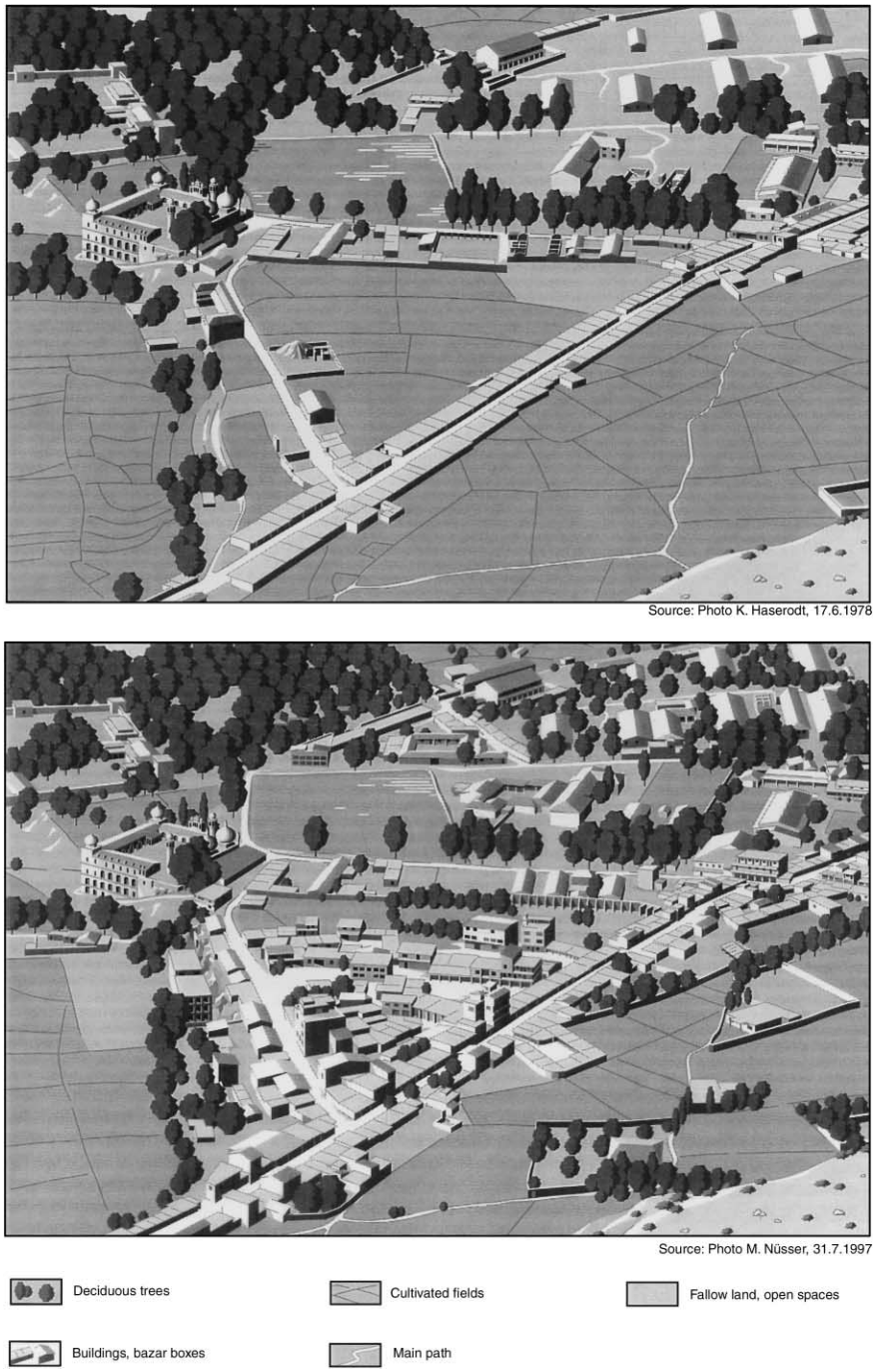

Fig. 9. Visual interpretation of urban landscape transformation in Chitral Town between 1978 and 1997.

incorporate the common technological and organizational knowledge of local mountain farmers, handed down through generations by cultural transmission. Thus, the term *traditional ecological knowledge* refers to historical and cultural continuity in local resource management systems based on ecological knowledge of dealing with the dynamics of the ecosystem (Berkes and Folke, 1998).

The irrigated mountain oases Phargam and Shagrom can be regarded as *traditional landscapes*. According to Antrop (2000, pp. 21–22), *traditional landscapes* reflect and combine great natural diversity of the environment and cultural diversity of the land-users. In most cases, such landscapes evolve slowly and land-use and land-cover change can be integrated with natural conditions and previous cultural and economical patterns. To the present day, the observed landscape transformation in the village environs shows some positive aspects and can be interpreted as a response of the local mountain population in their struggle for subsistence and sustainable resource utilization. The irrigated agriculture is characterized by a high grade of adaptation to the natural resource potentials. Therefore, a gradual development of landscape structures and patterns determines the character and scope of cultural landscape transformation.

The development of the cultural landscape in the village environs of Chitral shows a high grade of coincidence with the situation in the Nanga Parbat area (Nüsser, 2000). Both the regional case studies—Chitral in the eastern Hindukush and Nanga Parbat in the north-western Himalayas—illustrate how peripheral mountain communities in harsh environments and remote valleys struggle for subsistence and sustainable resource utilization. Despite the increasing population pressure in the course of the past decades, the development of the cultural landscape in both regions does not justify generalizing phrases like landscape degradation or environmental disaster.

Chitral Town reveals a more complex transformation characterized by rapid urbanization and modernization processes caused by exogenous influences, which in turn accelerate the dynamics of change. The magnitude of land-use and land-cover change can be detected as an increasing building density and a decreasing area of irrigated fields and grassland. The expansion of the townscape results from a complex interaction of an increasing bazaar area and modern built-up areas with hotels, government offices, and residential areas. The dominant driving forces for this rapid development process are regional population growth, increasing exchange relations with the lowlands of Pakistan and within the valley of Chitral, extensions of governmental administration, and international economic factors such as mountain tourism.

6. Conclusions

As cultural landscapes in remote high mountain environments are holistic and dynamic entities, the understanding of landscape identity and transformation requires an integrated approach that takes into account the interactions between natural landscape structures (environmental aspects) and the human driving forces which have shaped and changed them (developmental aspects). Comparing terrestrial photographs of the same cultural landscape is an appropriate method to obtain a database on contemporary land-use and land-cover changes. Especially in the context of uncertainty concerning the character and extent of culturally induced landscape changes, repeat photography might help to cope with the problem of different interpretations of terms like ''sustainable resource utilization'' and ''landscape degradation''. Although uncertainties about the extent of recent landscape transformation can be significantly reduced, the problems still remain as how to evaluate the aspects of change and how the results of the retrospective approach can be used for prognostic development scenarios. The future impact of factors such as further increasing population pressure, migration, and socio-economic change on the landscape structures can not be predicted. Bridging the gap between environmental and developmental issues remains of crucial importance for a better understanding of cultural landscape transformation. Making the connection between micro-level behavior of local communities and macro-level changes in the landscape structures and patterns remains a major research challenge.

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