KĀGBENI –
CONTRIBUTIONS TO THE GEOECOLOGY OF A TYPICAL VILLAGE IN THE KĀLI GAṆḌAKĪ VALLEY

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1. THE NATURAL SETTING OF THE VILLAGE AND EROSION PROCESSES

Kāgbeni is situated at an altitude of 2820 m a.s.l. and is a typical fan settlement in the upper Kāli Gaṇḍakī valley of central Nepāl. The alluvial fan owes its existence to transport and sedimentation processes of the Dzoṅ Chu, or Muktināth river. The alluvial fan of the Dzoṅ Chu extends far into the riverbed of the Kāli Gaṇḍakī. But severe lateral erosion activity along the fan front caused by the latter is responsible for a steep, almost 10 m-high erosion scarp. The erosion processes responsible for the steady retreat of the slope are still occurring, endangering parts of the main village and even the village gompa. Topographically, the village is spread out along the left riverbank of the Kāli Gaṇḍakī, on the fan surface high above the actual gravel bed of the Kāli Gaṇḍakī, and exactly where the Dzoṅ Chu river flows into it (cf. map enclosed).

The erosive power of the water plays an important role in ecological terms. Annually, during the monsoon period in summer, and coinciding with the melting of snow in the high mountains, the flow of water in the Kāli Gaṇḍakī rises to from 12 to 14 times its former rate, and the erosive power of the river increases correspondingly. It is particularly parts of the settlement, including the gompa, as well as entire portions of the agricultural land, that are most at risk from the regular erosive undercutting of river terrace rims.

Of catastrophic efforts, finally, is the sudden outburst of glacier or moraine lakes (cf. HAFFNER & POHLE, 2001). At the northern edge of the village, there is a steep +/- 185 m-high slope of solid Pleistocene conglomerate. At its base, the slope is mantled by recent coarse erosion material. When covered with vegetation, these slope sediments are relatively stable. Because of the nearly total removal of the vegetation cover, however, these slope layers are prone to water erosion and even to abrasion by the strong valley winds. Pediment-like cones produced by recent erosion and rockfall material are found along the foot of the slope and bordering the cultivated field area. The geomorphic processes responsible for the retreat of the slope and the weathering front in the conglomerates are still occurring, and ever since humans started to dig out the cave systems of Simbu Phu and Ḍaki Phu in the upper part of the conglomeratic layers (cf. land use map enclosed) they have been accelerating and intensifying the downslope transport of the sediments. At present at least one third of the original cave systems, and especially their front side, has therefore been destroyed by erosion, so that these systems now exist only in a rudimentary form. This indicates how tremendously the natural environment, particularly its relief, soils and vegetation, must have changed since man arrived in the Kāgbeni area. Up until today humans continue to play an active role in shaping their natural surroundings – and that, as we will see, in a very contradictory manner (cf. Chapter 5).

But in ecological terms, erosion processes play not only a destructive but also a very positive role. The almost stoneless, sandy-to-silty layer of sediment and soil is sometimes up to 4.5 m thick (cf. BAADE et al., 2001). This intensively used "field colluvium" owes its existence to the erosion and transport processes in the still glacerized source region of the Dzoṅ Chu, the stream that flows into the alluvial fan, while wind-borne sedimentation may have played a part too. As BAADE et al. stress, water from the network of irrigation channels that overlies the alluvial fan seems to be of fundamental importance for the accumulation and surface distribution of the sediments.

Because of their loess-like composition and texture (49.7% sand, 40.1% silt, 10.2% clay), the young fluvial sediments are the source material for fertile and easily cultivated soils. Black, fertile soils, so-called hortisols, have developed as a result of regular inputs of dung.

2. THE DAILY RECURRING VALLEY WINDS

What has proved to be a special kind of ecological handicap in climatic terms, and is regarded as unpleasant both by the native population of the Kāli Gaṇḍakī valley and by tourists, are the daily recurring valley winds that are familiar to the transverse valleys of the Himālayas (cf. MEURER, 1982; HAFFNER, 1997; HAFFNER & POHLE, 2001). These thermally induced anabatic winds, generated by the horizontal temperature gradient, are a function of the drop in air pressure between the Himālayan foreland and the Tibetan high plateau north of the main Himālayan range. The valley wind, which in the summer sets in around 10 o'clock, and in the winter around 12 o'clock, quickly and uniformly attains storm-force values (Fig. 1). On an average, the wind coming up the valley reaches velocities of 15 or 16 m/sec. Wind speeds of more than 20 and even 25 m/sec have regularly been recorded at exposed sites and in connection with relief-dependent jetlike effects (Fig. 2). The nighttime northerly wind, by contrast, blows at a barely noticeable 2 m/sec.

Intimately connected in origin with the basically positive thermic effects of large mass uplifts is a climatic phenomenon which, ecologically speaking, is by contrast detrimental: the storm-force winds that occur daily in the transverse valleys of the Himālayas and the bordering mountain ranges, on the one hand, and the wind storms typical of the plateaus of Central Asia, on the other. The southerly winds, which occur statistically more than 330 days annually, are responsible, in combination with a clearly developed system of slope winds, for the lack of precipitation and the aridity of the Himālayan transverse valleys. Farming is possible there only on irrigated oases, and the cultivation of fruit trees only with sufficient protection from the wind - behind walls and up side valleys. Even stones are set in motion by strong gusts of wind along the steep slopes. Modern windmills, which were installed near the village of Kāgbeni in 1993 to produce electricity, have since been demolished by the winds, which come in forceful bursts.

In statistically seldom cases, and regularly in January/ February, the system completely collapses. This occurs under cyclonic weather conditions manifesting as bad weather, with snowfall down to below 2300 m a.s.l. on the Tibetan plateau and down to 2500 m a.s.l. on the southern side of the Himālayas. As satellite pictures prove, these conditions may cause a solid cover of snow, if only of a few days' duration, in widespread parts of the Tibetan plateau. This snow cover, given its high reflective capacity, blocks any positive thermic effect coming from

the plateau as a heating surface. On the contrary, the Tibetan plateau and the snow-covered peaks become a source of cold.

The Tibetan plateau, and to an even greater extend the surrounding mountain chains, lie under the influence of the western subtropical jet stream. According to FLOHN (1970) this is a plausible explanation for the feared winter westerly storms in Tibet's long longitudinal valleys, and also, in my view, for the northerly storms that continue for several days, both day and night, in the Himālayan transverse valleys (HAFFNER, 1997). These northerly storms, passing down the valley of the Kāli Gaṇḍakī, attain top wind speeds that vie with the southerly winds heading daily up the valley during other seasons. No one dares to set out on a mount on such cold, stormy winter days. The mule caravans that are otherwise met throughout the year seek shelter behind house and village walls; all air traffic stops.

The northerly winter storms have not hitherto been described scientifically, not even in the specialized literature (FLOHN, 1970; SCHWEINFURTH, 1956). The local population, however, which has to put up with the wind conditions, distinguishes and classifies very precisely: the southerly wind is called *nampar*, and the oppressively cold stormy north wind *phamar*.

Once winter high pressure conditions come to prevail again on the Tibetan plateau, not only does the weather calm down, but also the daily southerly wind returns. The result is a noticeable rise in temperature, which may lead to apricot and peach trees blooming in January/ February.

Kāgbeni has the typical compact village plan, and all houses are flat-roofed and stand wall to wall. As indicated on the attached maps of Kāgbeni, the compact village plan can be attributed to a scarcity of land and represents an adaptation to the mentioned rough and extremely windy climate of the upper Kāli Gaṇḍakī valley (Fig. 2). In addition, of course, cultural rules were responsible for the original clustering.

3. KĀGBENI AGRICULTURE FROM AN ECOLOGICAL POINT OF VIEW

The alluvial fan of the Dzoṅ Chu extends far into the river bed of the Kāli Gaṇḍakī and features an oasis of irrigated and carefully terraced fields (cf. POHLE, 2001; cf. land use map enclosed). Given the low rate of precipitation (less than 300 mm/year) in the rainshadow of the main Himālayan range, and along with effect of the daily recurring dry valley winds, the arable land has to be irrigated. The fields are all terraced and levelled for irrigation by means of stone walls partly covered by grasses and thorny bushes. The contrast between the brown, steppe-like and mountainous landscape surrounding the village of Kāgbeni and the green fields is striking.

An annual average temperature of +/-11°C and a relatively mild winter (average January temperature of +/-3°C) allow for two harvests in Kāgbeni (cf. Fig. 3 cropping calendar, POHLE, 2001), and the range of cultivable products is relatively large. During the cold season, traditionally staple crops such as winter wheat and winter barley are grown. The latter is especially important for subsistence in the high altitude areas of the Himālayas, where roasted barley flour, or *tsampa*, is still highly valued by Tibetans and Thākālis. Wheat and barley, even in the form of *tsampa*, are fed to the riding and pack animals. During summer, when there is no frost, buckwheat and mustard are traditionally cultivated. From buckwheat flour a mushy but highly regarded porridge for young and old is made; the green leaves of buckwheat are used as

spinach. Potatoes, maize and vegetables such as cauliflower, cabbage or carrots were only introduced in the 20th century. The lone indigenous vegetables are the radish and a white turnip called *mulla*. From barley, buckwheat and even imported rice, homemade liquor, or *rakshi*, is distilled.

The harvest yields achieved in Kāgbeni are high, particularly the yields of barley and buckwheat, which often bring up more than a 20-fold return on the invested seed. The high yields in Kāgbeni are due mainly to natural preconditions, such as calcareous and silty soils, suitable thermic properties and sufficient irrigation, and secondarily to intensive farming practices. Thanks to the planting of a winter and a summer crop, the growing season is optimally exploited, irrigation being employed, and fertilization being carried out by means of high-grade natural dung.

As in other valleys of the dry Inner Himālayas, fruit trees such as apricots and peaches have long been cultivated in the upper Kāli Gaṇḍakī area. But the small fruits produced by the old varieties have not been able to compete with the high yield varieties grown today. Thanks to the activities of the "National Temperate Horticulture Research Centre" in Mārphā, modern fruit cultivation - in particular, apples as cash crop - has been introduced successfully in Mustāṅ, especially in the villages of Bārāgāũ and Pãcgāũ. One name intimately connected with the modernization of agriculture in Mustāṅ is that of Pasang Sherpa, an extraordinary man who came from East Nepāl, but was trained in France. As director of the Horticulture Research Centre, he introduced improved fruit tree varieties and taught modern techniques of plant propagation. A serious barrier to the further extension of fruit tree cultivation is the daily storm-like valley wind (HAFFNER, 1997). In wind-exposed places like the central parts of the valley bottom, the wind speed can easily reach more than 20 m/sec, whereas in areas sheltered by walls or inside the clustered village centre this drops to 1-2 m/sec (Fig. 2).

In Kāgbeni, arable and irrigable land is restricted by the extension of the alluvial fan of the Dzoṅ Chu (cf. map enclosed). This limiting factor is the ecological reason why in Kāgbeni the holdings of arable land per household are far too small to guarantee subsistence. Moreover, rice cannot be grown in Kāgbeni because of climatic constraints. As a result, this basic and highly favoured food has to be bought from outside. As the income from agricultural activities is insufficient, the inhabitants of Mustāṅ villages have traditionally relied on additional sources of income, such as livestock, trade and transportation business. Since the transit trade to Tibet has declined, many people secure further income through local business and tourism (lodges and inns). Mixed economies are characteristic of most Nepalese mountain communities and seem to be traditional in the case of the Kāgbeni population in particular, although the emphasis on particular economic activities may have shifted over time.

4. WATER SUPPLY AND IRRIGATION

Drinking and irrigation water is diverted by a channel system from the Dzoṅ Chu, the small river dividing the village into a northern part with the old village center of Kāgbeni and a southern part with more recently built houses (cf. land use map enclosed). The source of the Dzoṅ Chu is at a high altitude, near permanent snow and ice fields. Consequently, even in the dry season the Dzoṅ Chu provides sufficient water for Kāgbeni and was the main water supply for the village until 1975.

Irrigation water is needed mainly during the warmer season. Crops are usually irrigated in the first weeks after sowing and then every 15 to 20 days. Fruit trees also have to be watered, especially after planting. The supply of irrigation water is sufficient throughout the year – agro-ecologically most important in a semidesertlike natural surrounding caused by limited precipitation and diurnal valley winds.

5. ADAPTED USE AND OVERUSE OF THE NATURAL RESOURCES

Southern Mustāṅ has been inhabited by mountain dwellers since prehistoric times (cf. POHLE, 2000) in spite of ecological handicaps such as very limited rainfall, dry, stormlike valley winds and natural hazards in the form of floods and excessive soil erosion.

In Mustāṅ villages like Kāgbeni, settlement patterns, house forms and agricultural techniques, including water and soil management, are perfectly adapted to the natural environment. Nevertheless, the cultural landscape of the Kāgbeni area is characterized not only by carefully tended settlement and field complexes but also by degraded, overused forest relics and pasture lands.

Kāgbeni's people have remained up to today specialists in well-adapted forms of sustainable management of their natural resources, but at the same time they are the main agents in overutilization and irreversible degradation of their natural environment.

Heavy overgrazing and deforestation are the main reasons, and both have a long tradition. For centuries the only source for firewood and timber has been the coniferous forests growing naturally in the more humid, cloudy belt some hundreds of meters above the valley floor. At present, the people transport the needed firewood by mule from a relic juniper forest near Saṅdak on the way to Ḍolpo. One step in the right direction to solving the energy problem was the introduction of kerosene cookers and the provision of kerosene organized by the Nepalese government and supported by the Annapurna Conservation Area Project some ten years ago. The use of solar energy has meanwhile become very common in tourist lodges, especially to provide hot schower water. Additionally, for the past few years, Kāgbeni like other settlements in the southern Kāli Gaṇḍakī valley, has been connected to Nepal's electricity grid. In spite of a growing number of tourists lodging in the village, the use of firewood seems to have been reduced.

But nothing has changed in the tradition of the overutilizing the pasture lands. Especially in the desertlike area surrounding Kāgbeni, nearly all useful forage plants have been eradicated by overgrazing, so that the protection of soils by the natural vegetation cover has been reduced up to 90%. To get sufficient supplies of fodder, sheep and goats nowadays have therefore to climb far uphill.

As well known from other parts in Nepāl, we observe in the agricultural landscape of Kāgbeni and its surroundings a most spectacular contrast in the use and management of privately owned and communally owned land. From an ecological point of view, the privately owned arable land is perfectly maintained, whereas common pasture or forest land is heavily overused and characterized by degraded vegetation and soils.

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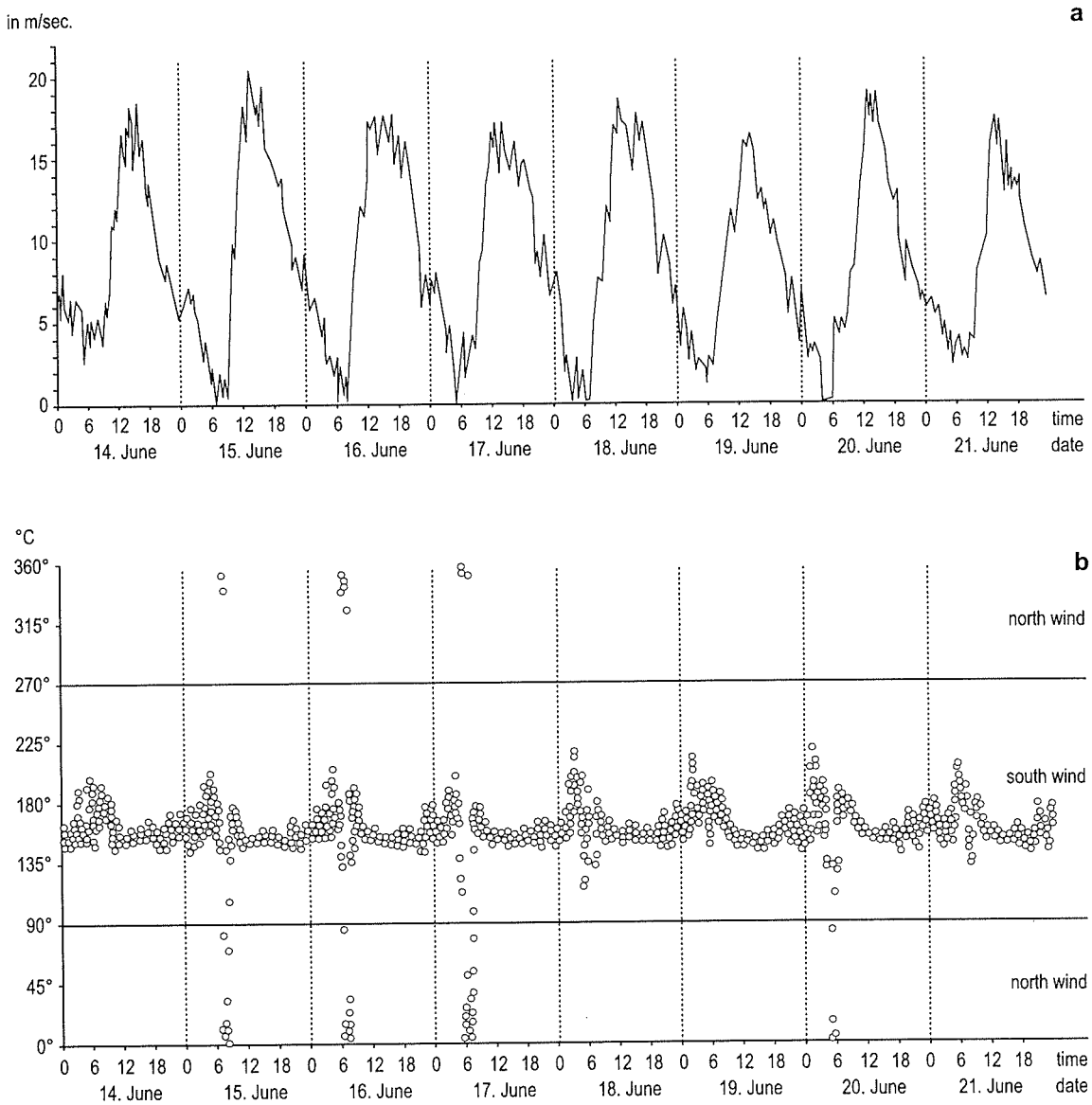

Fig. 1: Diurnal variation of wind speed (a) and wind direction (b) in the upper Kāli Gaṇḍakī valley near Kāgbeni (2820 m) measured 20 m above the ground. Data: Nepal Electricity Authority (cf. HAFFNER, 1997: 312).

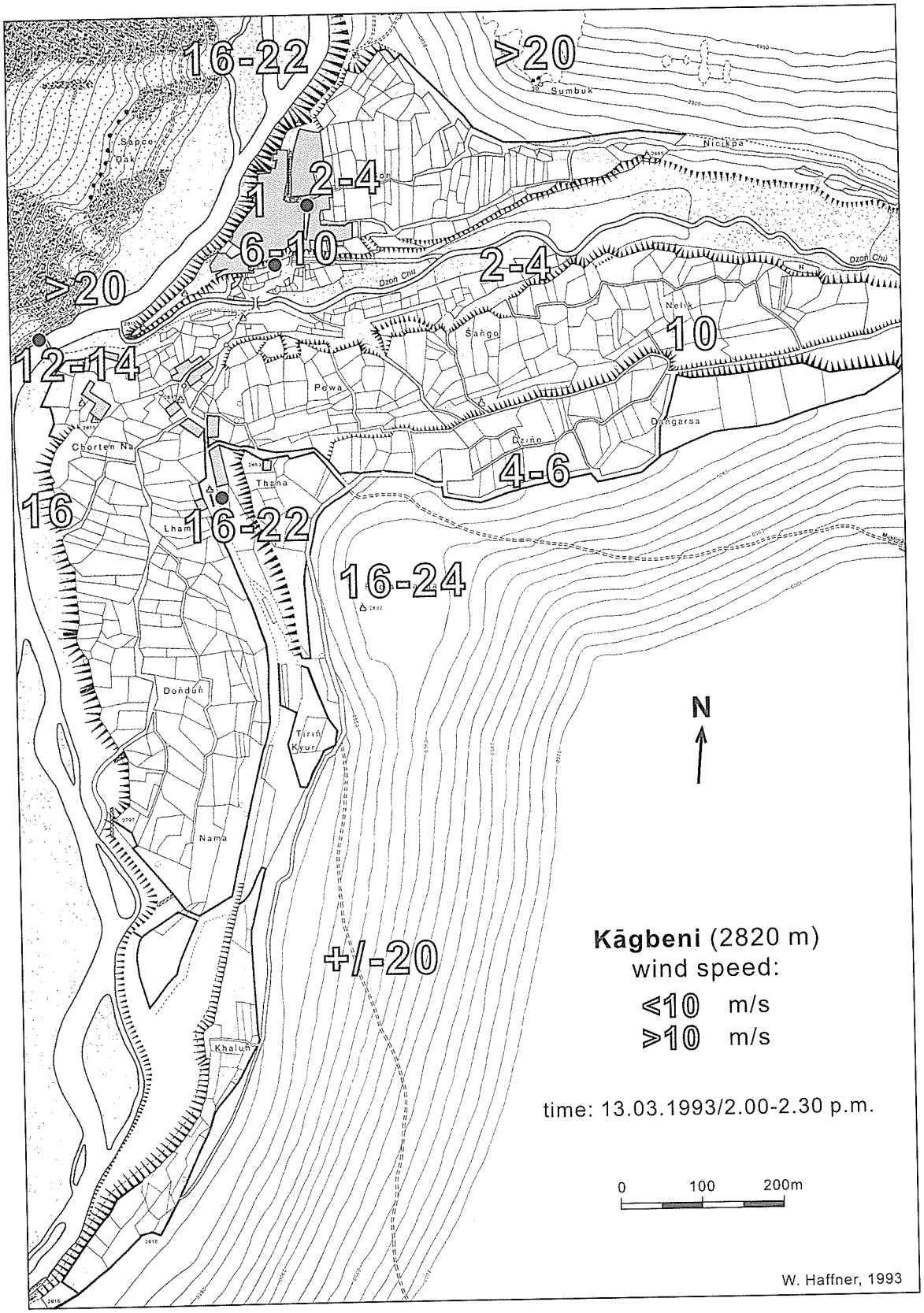

Fig. 2: Spatial variation of wind speed around Kāgbeni.