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Local perspectives on a global phenomenon—Climate change in Eastern Tibetan villages

Anja Byg [a,*], Jan Salick [b]

[a] Environmental Change Institute, Oxford University Centre for the Environment, Dyson Perrins Building, South Parks Road, Oxford, OX1 3AT, United Kingdom
[b] Missouri Botanical Garden, PO Box 299, St Louis, MO 63166, USA

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ABSTRACT

Tibetan villagers' perceptions of climate change and its impacts are very detailed and can give important insights into local concerns and processes of climate change. Perceived climate changes and impacts differed significantly even within a small geographic area. Furthermore, climate change was seen as a moral and spiritual issue. These interpretations affect how people deal with climate change and its impacts and which solutions are regarded as relevant. In order to effectively address climate change impacts at the local scale and to enable the process of adaptation, it is necessary to address a combination of perceptions, local variations, moral and spiritual interpretations, and locally relevant solutions.

1. Introduction

Global climate change models have increased greatly in number and quality over recent decades thereby improving the scientific understanding of past, present and future climate change. Nevertheless, there remains much uncertainty about magnitudes and impacts of climate change at any particular location and how best to prepare for these. While the primary manifestations of climate change are of a physical nature such as changes in temperature, rainfall, sea levels, and increased frequency of extreme weather events, the consequences or secondary manifestations are much more varied, including ecological, social, and economic impacts. How people in any given area are affected by climate change will therefore not only depend on the climatic changes themselves in that area but also on ecological, social, and economic factors (Adger and Kelly, 1999; Mendelsohn et al., 2006). People's ability to adapt likewise depends on a variety of factors including availability of resources (both state and individual) for adaptation, motivation, and information about the changing state of the environment and the links between human decisions and the environment (Adger and Kelly, 1999; Lambin, 2005). Climate change is thus a prime example of what has been called a "social ecological system" with factors from different domains interacting on different spatial and temporal scales (Holling, 2001; Berkes, 2002).

Social ecological systems cannot be adequately understood relying on science alone (Berkes, 2002; Kloprogge and Van der Sluijs, 2006; Laidler, 2006; van Aalst et al., 2008). Not only are these systems of such a complexity and with such large inherent uncertainties that adequate modeling is impossible (Kloprogge and Van der Sluijs, 2006), but the future pathways of such systems are intricately related with people's preferences and decision-making, which are themselves influenced by models and other efforts at understanding the system. In this context, local knowledge can promote the understanding of climate change and its impacts. In contrast to positivist science, which pretends to maintain the position of a neutral observer, situated outside the system and without influencing it, local people's observations are themselves embedded in the local cultural and social context that is so important in shaping the outcome of environmental changes (Laidler, 2006). In addition, local people's observations take place at the local scale, which is mostly absent from scientific studies and models (Wilbanks and Kates, 1999; Berkes et al., 2001; Laidler, 2006; van Aalst et al., 2008). Processes at the local level influence global level processes (and vice versa) (Wilbanks and Kates, 1999). Local knowledge can therefore make valuable contributions in gaining a better understanding of climate change. It can provide information about local conditions and redirect the foci of empirical investigations to issues that have been overlooked by science (Kloprogge and Van der Sluijs, 2006).

Documenting local perceptions of climate change is also important from a policy point of view, since local perceptions reflect local concerns (Danielsen et al., 2005) and focus on the actual impacts of climate change on people's lives (Laidler, 2006), which are dependent on local factors and cannot be estimated through models (van Aalst et al., 2008). In addition, local knowledge and perceptions influence people's decisions both in deciding whether to act or not (Alessa et al., 2008) and what

* Corresponding author. Current address: Systematic Botany, Department of Biology, Aarhus University, Denmark.
E-mail addresses: anja.byg@gmail.com (A. Byg), Jan.Salick@mobot.org (J. Salick).

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adaptive measures are taken over both short- and long-terms (Berkes and Jolly, 2001). Therefore, local observations and perceptions should be taken into account in efforts to understand climate change, its impacts, adaptation to it, and mitigation of it. Unfortunately, until recently, local knowledge of climate change and its impacts has largely been ignored by most climate change studies (with a few notable exceptions such as Vedwan and Rhoades, 2001; Krupnik and Jolly, 2002; Couzin, 2007).

Our study was concerned with the way climate change manifests itself in the knowledge, perceptions, and experiences of Tibetan villagers in China's Yunnan province. China has recently become the world's largest emitter of green house gases (http://news.bbc.co.uk/2/hi/asia-pacific/7347638.stm; Auffhammer and Carson, 2008). The Chinese government acknowledges the need for action to tackle climate change and it has ambitious plans for increasing the energy-efficiency of its industries (http://ukinchina.fco.gov.uk/en/working-with-china/environment; http://news.bbc.co.uk/go/pr/fr/-/2/hi/asia-pacific/7138826.stm). Economic growth, however, is still the top priority and domestic demand for consumer goods increases exponentially. This means that China's green house gas emissions are likely to continue rising rapidly in the foreseeable future (Auffhammer and Carson, 2008). The increased economic wealth may help China as a country to deal with the impacts of climate change; however, large populations, especially in the western parts of China, have been left behind during economic development. Like most other ethnic minorities in China, Tibetans live in these western areas and belong to the poorest segments of Chinese society (Gustafsson and Shi, 2003; Fischer, 2005). In this situation of economic and political marginalisation they are especially vulnerable to climate change impacts (Adger and Kelly, 1999).

In addition, the Tibetan plateau is already exhibiting some of the highest rates of climatic change in the world (Liu and Chen, 2000). Amongst the highly impacted areas are the Hengduan Mountains at the eastern end of the Himalayas. Tibetan people living in this area have access to a wide range of ecological zones and natural resources due to the region's varied topography (Weyerhaeuser et al., 2005). Eastern Tibetans take advantage of this geographic and ecological diversity in their intricate and complex livelihood systems using different zones as source for different products and at different times to sustain different activities (Salick et al., 2004, 2005). The use of a large variety of resources may confer higher flexibility and resilience to people's livelihoods (Berkes and Jolly, 2001); however, studies from other mountain areas have shown that climate change is already impacting mountain plant and animal species (Walther et al., 2005). Eastern Tibetans are therefore likely to experience dramatic changes in their ability to use and access many essential resources.

In addition to the material and practical implications of climate change, there are also substantial spiritual implications. In Tibetan cosmology many landscape features such as mountain peaks, glaciers, and waterfalls are endowed with spiritual value and are considered physical manifestations of different deities and spirits (Huber, 1994; Xu et al., 2005). In as far as climate change impacts these features – for example glacial retreat, diminishing snow cover of sacred mountains, changing rivers and vegetation – climate change may be imbued with spiritual significance. This spiritual dimension is also likely to affect how people perceive, evaluate and respond to climate change (Huntington, 2002).

In order to better understand the impact of climate change on Tibetans in the Hengduans, we conducted semi-structured interviews in six Tibetan villages in northwest Yunnan near the sacred mountain Khawa Karpo. The interviews centred on villagers' perceptions of climate change. The aim was not only to find out what changes are seen in the area and how these impact people's lives, but also to look at how these vary among locations and people and how they are interpreted.

2. Methods

2.1. Study area

The study was conducted in six Tibetan villages in Deqin County, Tibetan Autonomous Prefecture of Diqing, Yunnan province, People's Republic of China. The villages are situated in the vicinity of Mt. Khawa Karpo ("Meili Xue Shan" in Chinese). Mt. Khawa Karpo (6740 m), one of Tibet's primary sacred mountains, is the highest peak in the Hengduan Mountains of Yunnan and is also the physical manifestation of a powerful warrior god of the same name. As such, it attracts large numbers of Tibetan pilgrims following traditional pilgrimage routes around the mountain. Nowadays, the area also attracts large numbers of Chinese as well as smaller numbers of foreign tourists due to its scenic value featuring snow capped mountains, deep river gorges, rhododendron forests, glaciers, waterfalls, hot springs, and Tibetan culture.

Tibetans in the Khawa Karpo area live at a range of elevations, from relatively low-lying warm and dry valleys (around 2000 m) to high, cool and moist mountain areas (>3000 m). No matter where they live, most Tibetan people in the area make use of a diversity of ecological and climatic zones distributed along the elevational gradient (Salick et al., 2004, 2005). At the lowest elevations crops appropriate to warm climates (e.g., grapes) can be grown, while crops more suitable for temperate climates (e.g., wheat, corn, and walnuts) can be found up to intermediate elevation, and crops tolerant of cold (e.g., barley and buckwheat) are grown at higher elevations. Crop cultivation is supplemented by transhumance and collection of wild resources. Yak are taken up into high alpine areas to graze in the summer, and are brought back down to the villages when autumn approaches. Timber as well as non-timber products (e.g., medicinal plants) are collected from a range of different ecosystems, including intermediate to high elevation forests and alpine meadows at the upper limit of plant life (Salick et al., 2004, 2005).

The six villages included in this study are situated at elevations between approximately 2100 and 3300 m. They differ in a number of other ways such as size, the importance of tourism and access to roads, schools and shops (Table 1). Ethnically, all villages were predominantly Tibetan.

2.2. Methods

We investigated the following questions:

1. What climate changes have Tibetan villagers near Mt. Khawa Karpo noticed and how do these compare to changes noticed and predicted in scientific literature?
2. To what extent do perceptions of climate change vary among people and places in the area?
3. How do perceived changes impact the lives of Tibetan villagers in the area?
4. How do Tibetan villagers interpret and evaluate perceived changes?

Field work was carried out in June 2006. We used semi-structured interviews so that answers could be analysed by means of statistics to detect significant patterns among people and places with regard to perceptions, impacts and interpretations of climate change. In each of the six villages 15 people were interviewed. Only people above ca. 30 years of age were included in the survey to ensure that participants could make meaningful comparisons between the past and present. Because of practical limitations (time constraints and remoteness and small size of villages) participants were selected on the basis of equal gender and age representation, while limiting respondents to one person per

Table 1
Characteristics of the six Tibetan villages in northwest Yunnan visited during the study. Inhabitants were all Tibetan.

	Low elevation		Intermediate elevation		High elevation	
	Village A	Village B	Village C	Village D	Village E	Village F
Elevation (m)	2150	2200	2350	2400	3050	3275
Transportation and market access	Dirt road under construction, few km from larger road and county town	Along major paved road, 10 min drive from county town	1.5 h walk from nearest road	Paved road, bus connections to bigger towns	5 h walk from nearest road, horse transportation	Newly opened dirt road, 1 h drive to nearest town
No. of households	26	31	30	26	17	15
Tourism	no	no	some (mainly pilgrims and a few backpackers)	yes, major tourism center >100,000 people/year (2001) (pilgrims, Han Chinese and foreign backpackers)	yes (religious, Chinese and foreign backpackers)	no
Electricity	yes	yes	yes	yes	yes, but unreliable	yes
School	1/2 h walk	yes (grade 1–3)	yes (grade 1–4)	yes	15 min walk	1 h drive/3 h walk
Shops	1/2 hwalk	yes	yes	several	yes	no
Temples	no	yes	yes	yes	yes	yes
Rivers and streams	One creek	One creek	Two rivers	One river	Two rivers	No rivers or streams
Climate	Warm, low precipitation	Warm, low precipitation	Medium temperature medium precipitation	Medium to warm temperature, medium precipitation	Low temperatures, high precipitation	Low temperatures, medium precipitation

household (although the smallest village had only 14 households, so we interviewed two people from different generations in the same household). Interviews were conducted in Tibetan and/or Chinese where necessary with the aid of an interpreter. The interviews centred on people's perceptions of climate changes that had occurred in their life time (e.g., rain, snow and temperature), as well as associated phenomena (e.g., glacier size, avalanches and land slides, and harvest outputs; Fig. 1). People were also asked reasons for any observed changes and how these changes impacted their lives and the sacred mountains in the area. In addition, photographs from an expedition to the area in the 1920s, and repeat photographs of the same spots from 2003 were used to discuss changes in landscape features such as tree and shrub cover, snow cover and glacier size with those being interviewed (Fig. 2).

Informant responses were categorized and codified for statistical analysis. It was tested whether people's answers were related to village location, age, gender, percentage of their life-time spent in the village, and any 1st order interactions. Statistics included χ^2 (for non-parametric data), nominal and ordinal logistic regressions (for categorical dependent variables), ANOVA (Welch ANOVA in cases of unequal variance), ANCOVA, and linear regression (for continuous numerical dependent variables). Final models were built using a forward step-wise selection procedure. Significance was evaluated at $\alpha = 0.01$ to compensate for the large number of tests carried out (all analyses were carried out using JMP vers. 3.2.2).

In cases where answers were significantly related to village location, we further tested whether the differences between villagers' answers could be related to differences in environmental conditions. This was done by grouping two villages each into the following three categories: (1) low elevation villages with dry and warm climate, (2) intermediate elevation villages with a more humid and cooler climate, and (3) high elevation villages with a humid and cold climate. Low and intermediate elevation villages are relatively close together in terms of elevation alone (Table 1); however, they experience markedly different patterns of temperature and precipitation, and, hence, were grouped separately. Also, to test for possible effects of tourism, villages were grouped by amounts of tourism (one village with many tourists, two with some tourists, and three with few tourists).

3. Results

3.1. Observations of change

All the Tibetan villagers interviewed perceived changes related to climate change (Fig. 1). In accordance with other studies on local knowledge and perceptions, people's perceptions of climate change were not random (χ^2, see Fig. 1) and agreed with scientific climate records and models for the area (only data on average temperature, precipitation and glacial retreat were easily available; the two data sets can therefore only be compared with regard to general trends). There were, however, large differences among individual people as well as among different climatic factors. Some people had noticed many different changes and would venture many causal explanations, while other people had noticed only one or two changes, and were hesitant to voice any opinion with regard to possible causes. Likewise, some observations were more consistently mentioned by most people (e.g., warming temperatures, less snow, and glacial retreat), while there was much more variation in other observations (e.g., river levels and landslide incidences). However, in most cases general tendencies can be discerned. Thus, most people indicated that the annual amount of snow as well as rain had declined, and that the length of the snowy season was reduced (starting later and ending earlier); while no clear pattern emerged about the timing and length of the rainy season. Generally, people agreed on glacial retreat, warming

temperatures, early planting and harvesting, lower crop yields, increased crop diseases and insect attacks, and decreased avalanches. In general, no change was reported for crops planted or wild plant distributions.

3.2. Variation in perceptions

The statistical analyses indicated that a large part of the variation in people's observations as well as in perceived impacts of climate change were related to the village in which they lived (Fig. 1). When villages were grouped according to elevation and climate the effect in most cases was still significant, indicating that part of the differences among villages is related to climatic differences. The proportion of variation explained, however, was usually lower for climatic type than for village, indicating that there are other characteristics of villages that also come into play (discussed below). Grouping villages by degree of tourism did not yield any significant results.

3.3. Impacts on people's lives

Many impacts of climate change were reported by the villagers (Table 2). These included agricultural stresses (pests, pathogens, timing of planting and harvesting), increased health problems and spoilt food due to higher temperatures, improved hygiene (bathing is more pleasant in warmer weather), and reduced firewood needs. There was more variation among people interpreting impacts than in observing change. More than one third of the interviewed people

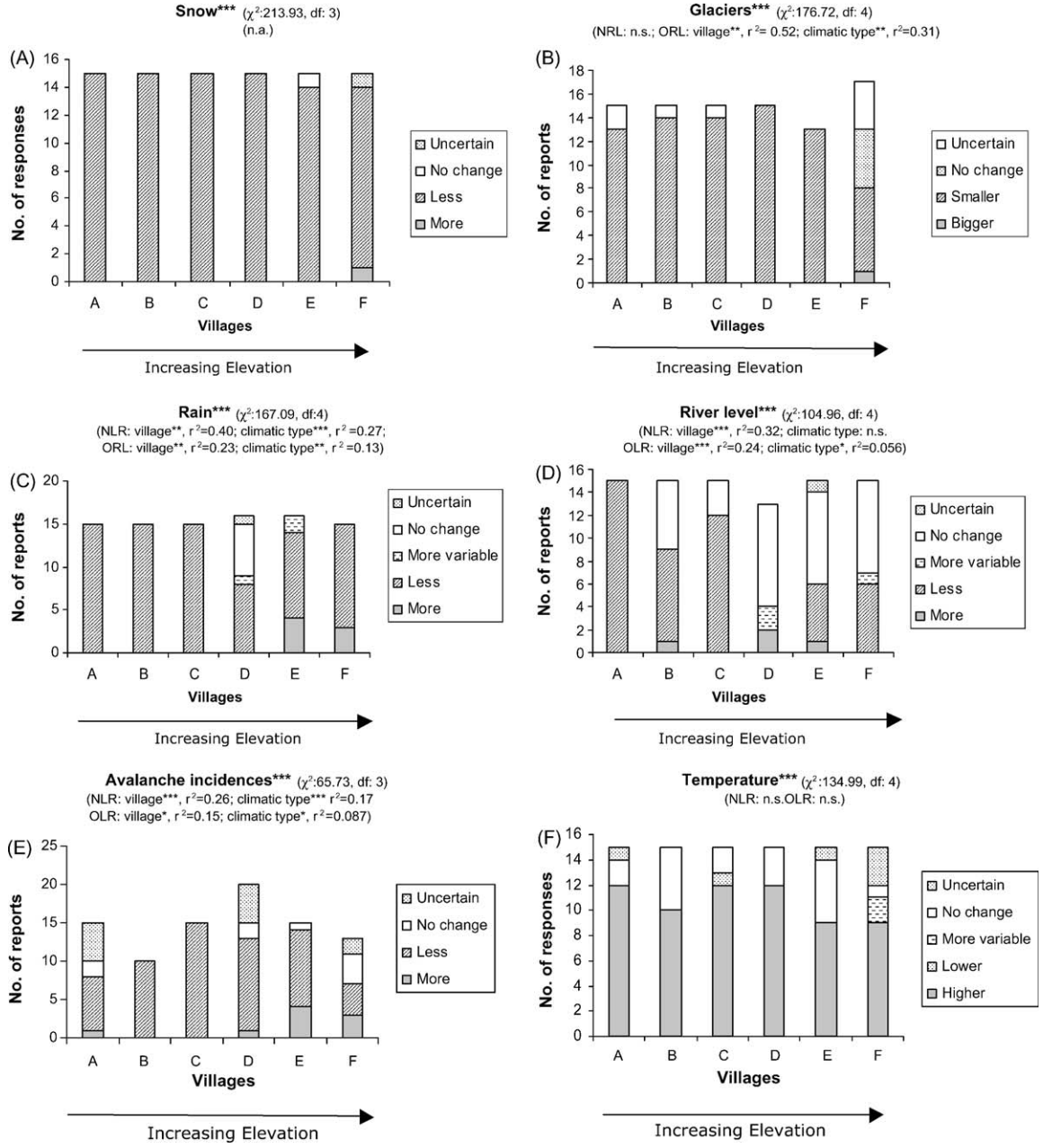

Fig. 1. Changes in climate related features discussed in interviews (present compared to earlier times) in six Tibetan villages (A to F, arranged in order of increasing elevation) in the eastern Himalayas. Answers were analysed for deviation from random patterns (χ^2 test, significance indicated by first set of asterisks) and for relationships with village, habitat, age, gender, and percentage of life-time spent in the village (NLR: nominal logistic regression, OLR: ordinal logistic regression). Significant factors are given in parenthesis. Significance levels are indicated as follows: n.a.: not analysed due to small sample size or little variation, n.s.: not significant, *: $0.01 > p > 0.001$, **: $0.001 > p > 0.0001$, ***: $0.0001 > p$.

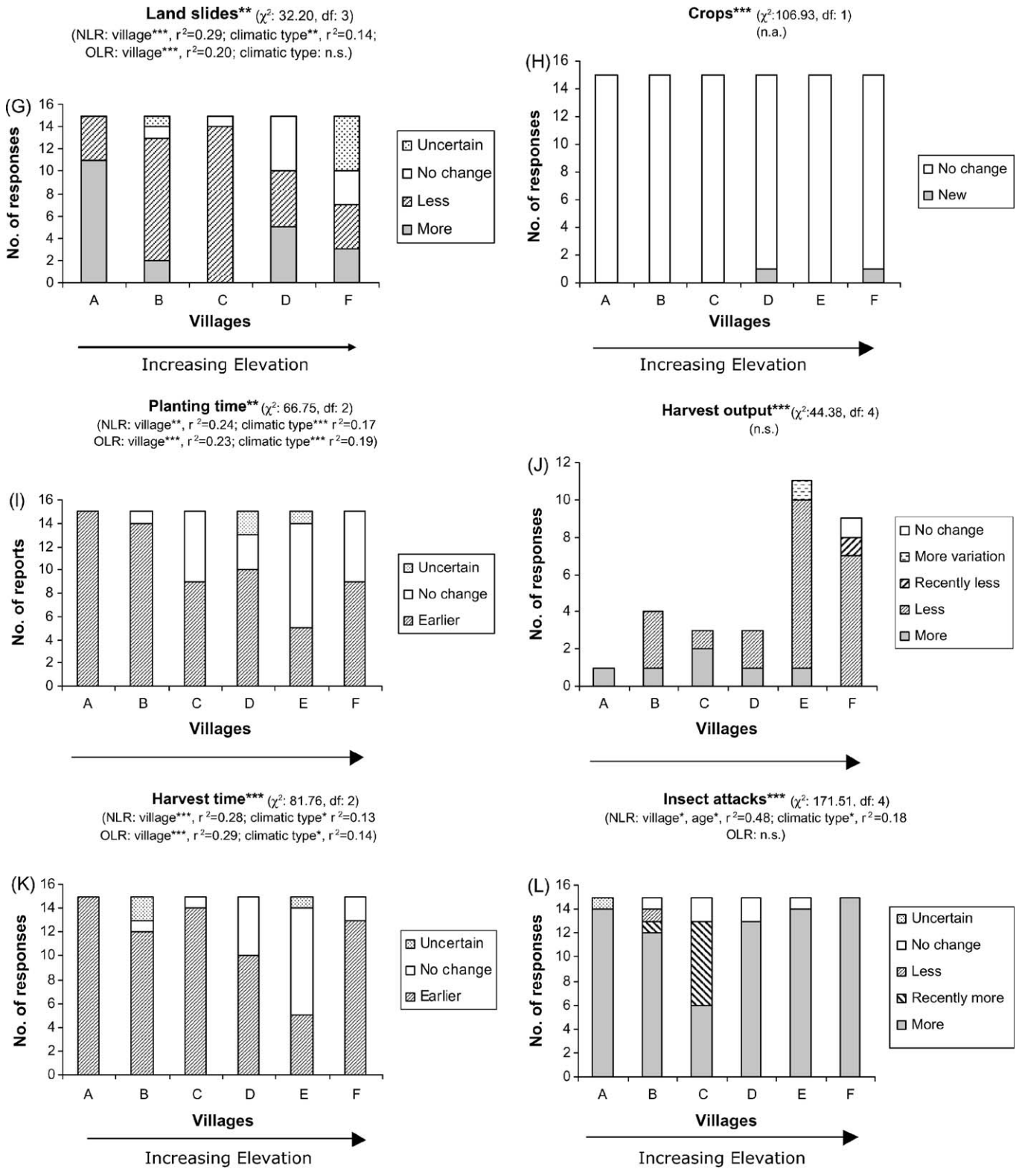

Fig. 1. (*Continued*)

did not report any impact on their lives. The majority of mentioned impacts were of a negative nature (63 as opposed to 19 that could be classified as positive impacts). The most frequently mentioned negative impacts of climate change were health related, and these were especially related to stomach problems as a result of eating spoilt food. As with observations of changes, impacts on people's lives were also highly related to which village they lived in (Table 2). When villages were grouped according to climate the effect was still significant, with lower elevation villages showing most negative impacts. Likewise, grouping villages according to

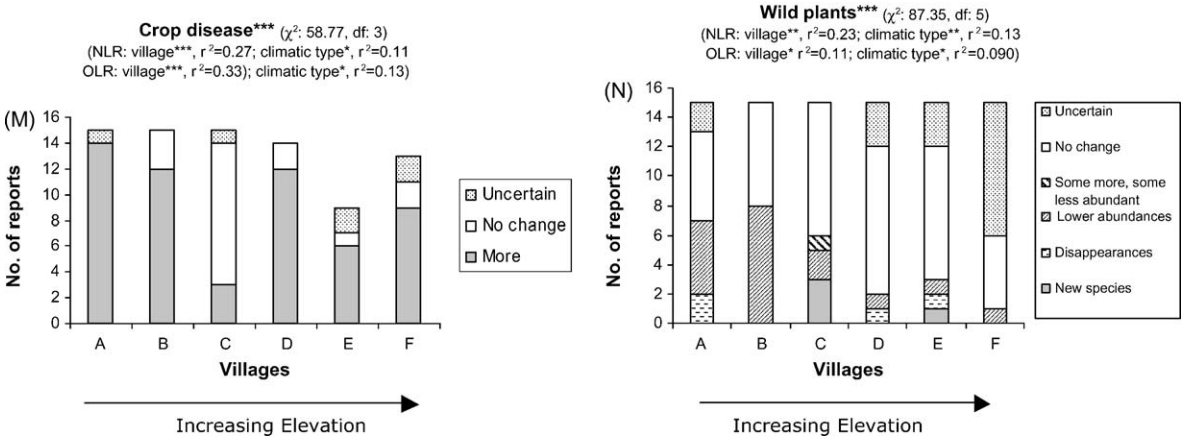

Fig. 1. (*Continued*).

level of tourism gave significant results with most negative effects reported from villages with low levels of tourism.

3.4. Interpretation and evaluation of perceived changes

The causes of climate change that people gave (Table 3) can be divided into two categories, although these are not always clearly distinct from each other. One type we shall call material causes. Examples of such material causes are that increasing temperatures were caused by the increasing use of electricity, that decline in rainfall was due to tree felling, and that glaciers were melting because garbage left behind by tourists absorbed sunlight and emitted heat. Explanations of interrelated changes also fall in this category, for example increased insect attacks on crops were seen to be caused by a decrease in the amount of rainfall. The other category of explanations we shall call spiritual. Examples are that harvests were bad due to the violation of taboos, such as hunting or collecting medicinal plants on sacred mountain sites, and that the lack of rain was due to a hydroelectric power company angering the mountain deities by dynamiting the mountains. While the majority of spiritual reasons had strong moral implications (indicating some form of human misconduct), a minority of spiritual explanations were morally neutral and more fatalistic, simply stating that the observed changes were an intrinsic part of the cosmological order. A number of causes were seen to work in both a material and spiritual manner. For example, pollution by tourists was, in addition to its heat absorbing effect, also said to anger the mountain deities who therefore brought on climate change. The different material and spiritual implications of the same causal factor were at times mentioned by the same person, but more often, some people would stress spiritual causation while others would stress material causation. Although the distinction between material and spiritual explanations primarily reflects the impression we as outsiders derived from our discussions with Tibetan villagers, a later follow-up study revealed that Tibetans apply a similar distinction.

In most cases material as well as spiritual explanations were connected to human behaviour. In some instances, the behaviour identified as a root cause was of a general nature such as people driving more cars, putting up solar water heaters, and using more electricity. However, often the causal behaviour was identified with a particular group, that is, either with outsiders or Tibetans. Outsiders bearing blame included tourists (polluting the area with plastic garbage, and not showing due respect to sacred areas), and

Table 2
Impacts of climate change on people and sacred mountains reported by 90 informants in six eastern Tibetan villages. Nominal and ordinal logistic regressions were carried out to identify relationships between informant responses and the following characteristics: age, gender, proportion of lifetime spent in the village, and village location. The second column lists informant responses. Numbers in parentheses indicate the number of people giving each answer. Impacts on people's lives were subsequently categorized as positive, negative or neutral and analyzed again. The third column indicates the type of analysis carried out (NLR: nominal logistic regression, OLR: ordinal logistic regression) and which factors were found to be significant. Where "village" was identified as a significant factor, the test was repeated after replacing village with a grouping of villages according to climatic type.

	Reported impacts	Significant factors related to responses	
		NLR	OLR
People and quality of life	Health problems (46), improved hygiene (4), declining harvest (8), fewer resources (5), able to spend more time outside (5), miscellaneous (13) no impact (34)	village*** (r^2 = 0.29) climatic type*** (r^2 = 0.22) tourism*** (r^2 = 0.11)	
	Evaluation of change: positive (19), negative (63)		village*** (r^2 = 0.42) climatic type*** (r^2 = 0.38) tourism*** (r^2 = 0.28)
Sacred mountains	Observed changes: less snow (27), fewer trees (9), miscellaneous (5), no change (19), don't know (13)	village*** (r^2 = 0.33) climatic type*** (r^2 = 0.20)	
	Concerns/interpretation of mountain changes: bad luck (11), disaster (4), health problems (7), mountains are angry (10), worried (10), worse harvest (5), weather change (4), mountains not affected (6)	village** (0.31) climatic type** (r^2 = 0.16) tourism* (r^2 = 0.12)	

n.s.: not significant.
* $0.01 > p > 0.001$.
** $0.001 > p > 0.0001$.
*** $p < 0.0001$.

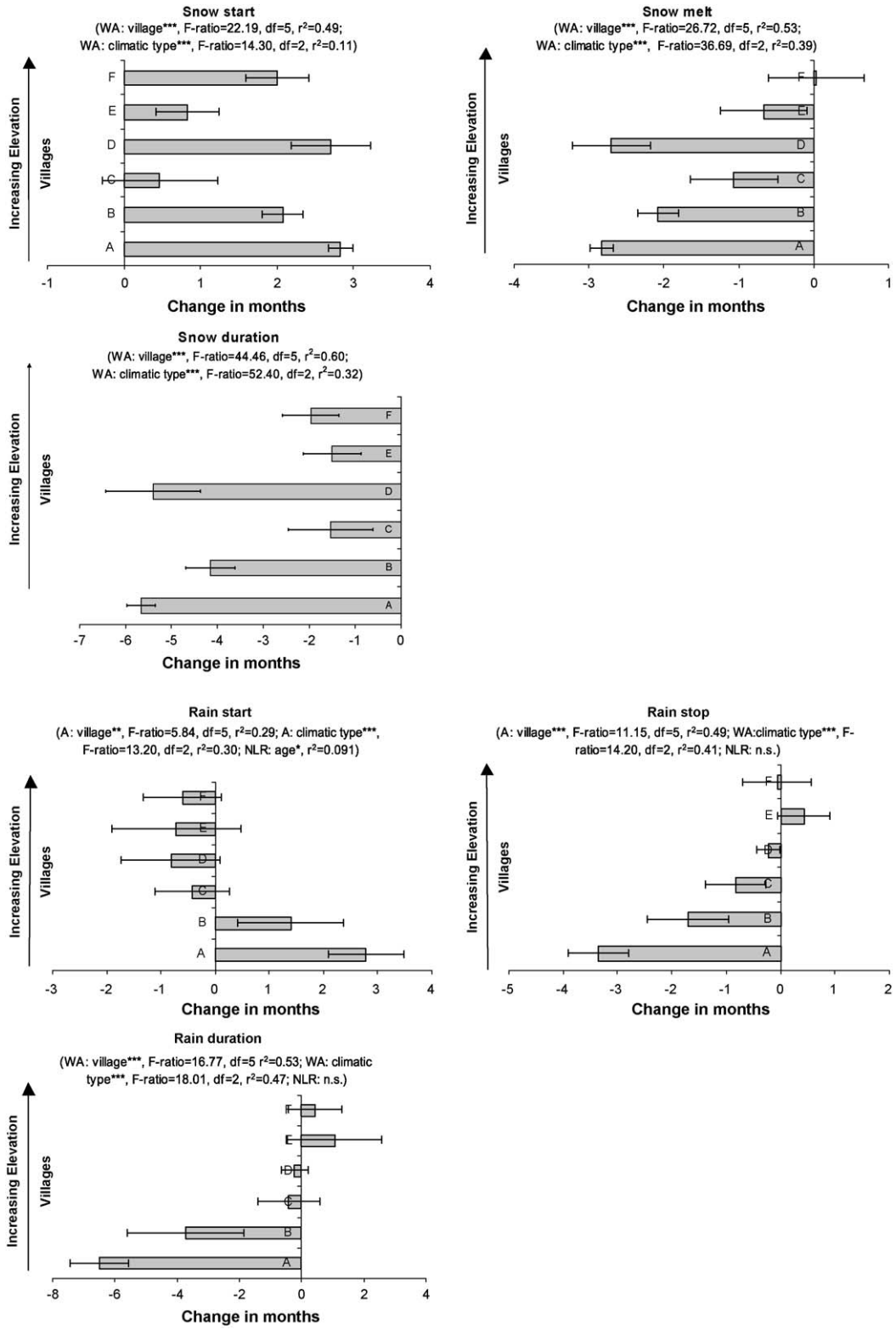

Fig. 2. Changes in the beginning, end and duration of rain and snowy seasons as indicated by villagers in six Tibetan villages (A to F, arranged in order of increasing elevation) in the eastern Himalayas. Answers were analysed for relationships with village, habitat, age, gender, and percentage of life-time spent in the village (A: ANOVA, WA: Welch ANOVA). Significant factors are given in parenthesis. Significance levels are indicated as follows: n.a.: not analysed due to small sample size or little variation, n.s.: not significant, *: $0.01 > p > 0.001$, **: $0.001 > p > 0.0001$, ***: $0.0001 > p$.

various companies and government representatives (road and hydroelectric power plant construction companies violating sacred landscape features). Fellow Tibetans were mainly blamed for religious misconduct (e.g., failing to make offerings and pray, or violating taboos) or for not preventing others (e.g., the tourists) from offending the local deities.

In most cases people's statements of causation could not be related to any of the tested variables. Only in the case of landslide

Table 3
Causal explanations given by people in six Tibetan villages in the eastern Himalayas for their observations of climate related changes. The first column indicates the type of climate related change to which the explanation refers. The second column gives the different explanations encountered (number of times each explanation was mentioned is given in parentheses). The third column indicates whether answers were found to be related to a set of independent variables tested by nominal logistic regression.

Feature	Explanations	Significant factors
Climatic change in general	Cosmology (2), environment (12), modern day life (32), local religious misconduct (15), outsiders' religious misconduct (32)	village *** ($r^2 = 0.18$)
Snow	Modern life (3), local religious misconduct (1), outsiders' religious misconduct (7)	n.a.
Rain	Cosmology (2), modern life (7), local religious misconduct (4), outsiders' religious misconduct (5)	
Glaciers	Don't know (1), cosmology (1), environment (22), modern day life (18), local religious misconduct (3), outsiders' religious misconduct (21)	
Rivers	Environment (3), modern day life (2), outsiders' religious offence (1)	n.a.
Avalanche**S**	Environment (8), life circumstances (1), local religious misconduct (1), outsiders' religious misconduct (1)	n.a.
Land slides	Environment (18), policy (1), modern life (16), local religious misconduct (5), outsiders' religious misconduct (1)	age* ($r^2 = 0.15$)
Temperature	Environment (9), modern day life (6), life circumstances (6)	
Crops		
Types	Environment (1), policy (1)	n.a.
Planting and harvesting time	Environment (10), policy (1), modern day life (19)	
Harvest output	Environment (17), policy (1), modern day life (5), local religious misconduct (2), outsiders' religious misconduct (2)	
Insect attacks	Environment (16), modern day life (4), local religious misconduct (1), outsiders' religious misconduct (4)	n.a.
Crop diseases	Environment (5), modern day life (3), local religious misconduct (2), outsiders' religious misconduct (1)	
Wild plants	Environment (14), policy (1), modern day life (7)	

n.a.: not analysed due to small sample or little variation; **$0.001 > p > 0.0001$.
* $0.01 > p > 0.001$.
*** $p < 0.0001$.

frequencies could people's perceptions of causation be related to their age, while the causes given for climate change in general were related to village (Table 3).

When asked about the effect of climate change on the sacred mountains, answers could roughly be divided into three groups: (1) those who thought that the mountain deities were affected by climate change, (2) those who saw the changes as being caused by the mountain deities, and (3) those who saw no connection between climate change and mountain deities or who were not sure. Many people seemed hesitant about these more theological questions, and it was not always very clear which were thought to be the causes and which the effects. The type of answer people gave was related to which village they lived in, as well as to the climate and the amount of tourism (Table 2). In high elevation villages and villages with high levels of tourism, people would more often blame outsiders for being the cause of observed climate change than in lower lying villages and villages with low levels of tourism.

4. Discussion

We hoped to document to what degree climate change is already a perceived phenomenon in Tibetan villages, how it impacts people's lives and how this varies among people and locations in one area.

4.1. Observations of change

Our interviews in six Tibetan villages showed that people had noticed a variety of climate change in great details. Furthermore, people's observations fitted with scientifically recorded changes in temperature, precipitation and glacier change (IPCC, 2001; WGMS, 2005). In some cases, people detailed recent short-term changes in comparison to longer-term trends. People would thus qualify their responses with statements such as "since the 1990s" or "in the last 2 years". This attests to the specific nature of their observations in space and time, and to their evaluation of deviations from the normal over time, even discerning between a few "odd years" and more long-term trends. Other studies have shown that people evaluate climate change in comparison with what is considered ideal weather patterns (Vedwan and Rhoades, 2001), but also with regard to the amount of variability that is considered normal in a location (Jolly et al., 2002).

The interviewed people in the villages had never heard of the phenomenon of global climate change and therefore regarded the changes they were experiencing as local phenomena (see section below on people's interpretation of observed changes). Their lack of awareness corresponds to the general lack of discussions on climate change issues in China. Despite the fact that the Chinese government acknowledges the significance of climate change and the need for action (nationally and internationally) at the time of field work (2006) climate change had not yet become a major issue for the Chinese media (Yang, personal communication). It has previously been shown that media can play a decisive role in shaping people's perceptions of climate change (by strengthening or undermining faith in the science behind it, see Boykoff, 2008), but due to the lack of media interest in the issue, the observations reported in this study are not likely to have been influenced by such external sources of information.

Scientists are often sceptical about the reliability (as seen from a scientific point of view) of observations made by non-scientists (Huntington, 2000; Berkes, 2002). One of the points that is sometimes raised is that recall of past events may be influenced by idealised images of how things were (or should have been). While experimentally based studies have shown that expectations may indeed influence recall of events (e.g., Freeman et al., 1987; DiMaggio, 1997), comparisons of local observations of climate change in the Arctic with scientific results support our notion of the accurate and genuine nature of local observations on processes of climate change (Kofinas et al., 2002). In our case, the possibility that people's answers were due to a romanticised image of the past, where everything, including the weather, was remembered as having been better, does not seem very likely. As mentioned above, the changes reported by people were in accordance with those recorded and predicted by scientific models. In addition, people reporting the same observation were in some cases evaluating the same change differently. This was the case with people's observations on temperature changes. The majority of informants thus agreed that it was warmer now than before. However, while

people in low-lying villages uniformly complained about the oppressive heat, people in the highest villages regarded the increased temperature as an improvement.

4.2. Variation in perceptions

People's observations were in general not dependent on their gender or age. Men and women, older and younger people all had observed changes. This is in contrast with another study from the Arctic where it was shown that older people had a tendency to report more change than younger people (Alessa et al., 2008). The lack of correlation with age in our study seems to indicate that noticeable changes have taken place within a relatively short time span (<20 years). Even the younger informants (in their 30 s) had thus noticed changes deviating from the pattern of normal year-to-year variation.

Most observations were significantly related to which village people lived in, and to the considerable differences in climatic conditions among villages. Due to the steep topography there are large differences among villages in proximity. Elevation, exposure, and aspect determine temperature, precipitation, and wind. It is therefore to be expected that observations of changes as well as their impacts vary with location. Most previous studies of this type have taken place in the Arctic. These studies have likewise stressed strong local differences in climate change and their impacts (Fox, 2002; Kofinas et al., 2002). This is one of the great advantages of incorporating local people with climate change research: they can give information on local climate change unaddressed by global climate change models.

The lower amount of variation explained when we replaced "village" by "climate" indicates, however, that there are other factors not included in the analyses which differentiate the villages. How environmental factors impact villages and are perceived not only depend on the environmental factors but also on differences such as village age, history, available technologies and predominant subsistence activities (Quinn et al., 2003). While subsistence activities in Eastern Tibet depend on village elevation, they also are influenced by factors such as agricultural extension workers, NGO's, government policies, and by the development of alternative income sources such as tourism. These also influence the availability of technologies in the villages (e.g., grape cultivation). Changes in technologies or activities carried out on the land influence how environmental phenomena such as weather are perceived by people (Ingold and Kurttila, 2000).

4.3. Impacts on people's lives

People reported both negative and positive impacts of climate change on their lives. The majority (63 out of 82) of all the reported impacts, however, were negative (Table 2). Such a mix of negative and positive effects accords well with findings of other studies (Berkes, 2002; van Aalst et al., 2008). There was large variation in the impacts of climate change reported by people. Like change observations, part of this variation was related to village location. How changes are evaluated depends on cultural and socio-economic factors, and on local conditions and local changes. Although the majority of people in all villages reported that temperatures had increased, in lower villages this increase was experienced as a decidedly negative factor. The higher summertime heat was regarded as oppressive by the people in the lower regions, causing people to feel weak, food to spoil, and flies and mosquitoes to proliferate. In contrast, in the higher villages where winters used to be extremely cold with heavy snow fall, the temperature increase meant that people did not need to collect so much firewood for heating their homes, they could spent more time outside, and could bathe and wash more frequently. However, people in the high villages also reported negative impacts from climate changes such as reduced harvest output (due to pests, diseases and inappropriate crop varieties), reduced availability of resources (afforesting pastures, for example), and increased health problems.

In addition to elevation and specific climatic conditions of the villages, tourism also affected how Tibetans reported impacts of climate change. Tourist numbers per village ranged tremendously from none to ten thousand. In villages which received many tourists, fewer people reported negative impacts on their lives than in villages receiving few or no tourists. This may be due to the decreased dependency on agriculture (which both is heavily affected by climate change and necessitates constant outdoor activity) and the increased monetary income which tourism provides for people, and which may buffer people against the impacts of climate change (e.g., by enabling them to buy refrigerators to keep their food from spoiling).

At the time of our study, the negative impacts reported most often were related to health. Many models of climate change impacts deal with health problems such as vector-borne diseases (e.g., malaria which has yet to appear in the study area although mosquito populations are increasing), or with direct health impacts of extreme weather events (e.g., heat waves, floods). There has been little focus so far on less dramatic, but no less tangible, health impacts such as food spoilage as reported here and noted among the Inuit (Berkes, 2002). Again, this illustrates the value of including local experiences in studies on climate change impacts, mitigation and policy to assure addressing problems experienced by local peoples.

Just as climate change is an ongoing process so are its impacts. The main problems today may not be the main problems tomorrow. Other problems such as declining harvests, constancy of water supplies, and increasing problems in planning such activities as sowing and harvesting due to more unpredictable weather patterns were mentioned only occasionally in our interviews, but may well increase in the future. The occurrence of new and hitherto unperceived impacts and problems may also increase. A list of perceived impacts such as the one presented here should therefore not be seen as a fact sheet of enduring value, but rather as a snap-shot in time and place. In addition, problems created by climate change never act in isolation but interact with and vie for attention with other social, economic and ecological problems, which need to be addressed simultaneously (Fox, 2002). One third of the respondents stated that climate change did not impact their lives, despite the fact that all respondents had noticed changes in climatic conditions. In the study area, other more pressing issues include economic development and government policies such as the ban on burning pastures, ban on logging and ban on hunting (Salick et al., 2005).

While material impacts of climate change have received much attention by researchers, media, and policy makers, our interviews show that there are also considerable non-material implications of climate change including anxiety over the spiritual implications of climate change.

4.4. Interpretation and evaluation of perceived changes

As mentioned above, people in the six Tibetan study villages were not aware of the phenomenon of global climate change. Therefore, neither perceptions nor interpretations had been influenced by external sources of information such as media, state agencies or NGO's. They assumed that changes were local and were often interpreted within frameworks applied to local weather and climate phenomena.

Many of the local causes mentioned involved moral issues, as well as a distinction between Tibetans and outsiders. These elements are most clearly illustrated by the frequent mention of a fatal Sino-Japanese mountaineering expedition in 1991 (Xu et al.,

2005). Seventeen mountaineers lost their lives in an enormous avalanche during an attempt to climb the heretofore unconquered summit of Mt. Khawa Karpo. Both prior to and after the fatal expedition, local Tibetans voiced their protests against the attempt at climbing their sacred mountain. According to local people, the mountaineering intrusion brought forth the wrath of the warrior god Khawa Karpo (whose physical manifestation is the mountain), who then hurled the avenging avalanche upon the intruders (Litzinger, 2004; Xu et al., 2005). Many people interviewed still referred to the incident, both as a turning point from which climate change dated and as an example of the causative link between outsiders' presence and actions on the one hand, and climate conditions on the other. The attempt at climbing the sacred mountain was only the most extreme example of the ongoing irreverent behaviour of outsiders, whose presence in itself many perceived as polluting (Huber and Pedersen, 1997). Other blasphemous actions mentioned include washing (especially feet) in sacred lakes and streams, walking on sacred glaciers, and blasting holes into the sacred mountains for development.

The same elements are found in traditional Tibetan interpretations of environmental and meteorological phenomena (Huber and Pedersen, 1997; Kapstein, 1998). Weather has traditionally been viewed as a local phenomenon determined largely by local deities. Adverse weather conditions such as droughts, hail, or blizzards accordingly were interpreted as a sign of the deities' anger caused by neglect of religious duties or breach of taboos. The perpetrators (and therefore the causal agents of the adverse climate conditions) could be local Tibetans or non-Tibetan outsiders. In the latter case, the mere presence of outsiders could be offensive to the deities (Huber and Pedersen, 1997). Similarly, during this study, a rain storm was ascribed to the visit of a group of Japanese tourists. Bad weather is thus a moral as well as an ethnic issue.

While offenders are often identified as individual persons or groups, the consequences (adverse weather conditions) fall collectively on people in an area (Epstein and Peng, 1998). Many Tibetan deities inhabit a specific locality and their power and wrath are likewise of a local nature (Huber, 1994; Huber and Pedersen, 1997; Huber, 2006); however, the relationship between local people and local deities is not always negative. The local people living near Mt. Khawa Karpo have a special relationship with the mountains and their respective deities. The local Tibetans are the guardians of the sacred peaks. As such, Tibetans have a duty to make sure that the religious taboos concerning the mountains are observed. For example, in sacred areas, hunting, tree felling, and collecting medicinal plants (by everyone but Tibetan doctors who perform prayers and rituals) are taboo (Huber and Pedersen, 1997; Anderson et al., 2005). In return, the mountain spirits protect and help people in the area (Epstein and Peng, 1998). Violations of taboos (by the local people or outsiders), on the other hand, cause misfortunes in the area, which often, but not always, take the form of adverse environmental conditions (examples of non-environmental vengeful actions by angry deities include diseases, accidents, death, or general misfortune). Many of the villagers interviewed thus felt that they were suffering the consequences of the misdemeanours of others. However, explanations clearly depended on local circumstances. For example, in villages with heavy to moderate tourism blame fell often on the presence and actions of outsiders while people in villages with less tourism were more likely to point to other Tibetans as the main culprits. One monk felt that that Tibetans deserved collective blame for not having prayed enough during the Cultural Revolution.

Despite the fact that most people regarded the observed climate changes as local phenomena, some people mentioned more general causes, such as overpopulation, increased use of electricity or a change in the distance between the earth and the sun.

While some saw climate change as a result of the gods' anger, others saw climate change as harming the gods, weakening their power to protect humans and to answer prayers. Snow and glacier melt especially worried Tibetans as expressed in the following statements:

> "The mountains are not as beautiful any more, and they do not protect people as they used to." (man, 29 years)

> "I am worried that the earth will be destroyed if the snow disappears completely." (woman, 85 years)

> "If the snow disappears, people will disappear from the earth." (man, 57 years)

With regard to cause and effect, many people did not seem to be very certain of the exact nature of the relationship between environment, humans and the deities. However, the majority seemed to have a strong sense of human actions as a root cause (either by acting directly on the environment or by influencing the gods, either angering or weakening these).

No matter whether climate change was interpreted as a force impacting the protective deities or as a sign of the deities' response to human misconduct, climate change caused anxiety (weakened deities) and frustration (deities angered by the behaviour of others). In both cases (as well as with the scientific interpretation of climate change), Tibetans suffer the consequences of acts that are largely outside their own sphere of influence.

Scientists as well as policy makers often find it difficult to accept explanatory concepts that diverge from their own especially where these are based on spiritual concepts (Berkes, 2002). Fortunately, it is not necessary to achieve complete consensus in order to work towards a common goal together. Examples from the Arctic show that it is possible for scientists and local people to work together and profit from each other's knowledge and insight when the relationship is based on mutual respect, particularly if science can be accepted as one way of knowing among many others (Berkes, 2002). Our study showed that in many instances Tibetan villagers are concerned about the same issues as scientists, such as glacial retreat, deforestation, tourism, and increasing use of electricity and transportation. Even where interpretations of mechanisms are not the same, such shared concerns may constitute common ground where scientists, policy makers and villagers' interests converge. At the same time it is, however, also necessary that villagers' concerns about the spiritual implications of climate change are taken seriously even where these are not shared by the scientists and policy makers. The anxiety and psychological stress caused by these concerns are very real and influence what actions are considered appropriate and acceptable by the people in the area.

5. Conclusion

Models and measurements of climate change are constantly developing and becoming more detailed and accurate. Nevertheless, models and other scientific instruments are not sufficient to understand or tackle complex problems such as climate change. Climate change is not a purely physical or even solely an environmental phenomenon, but also has social, cultural, economic, and, as has been shown here, spiritual and moral aspects. To understand these phenomena local actors and their accounts are directly relevant. Only local people can explain how climate change becomes manifest locally and how it is evaluated, interpreted and handled by the affected people. While local observations cannot substitute for scientific measurements and models, they are important supplements, detailing local phenomena and perceptions

and giving insight into local concerns. Local observations can inform scientists by directing attention to overlooked aspects and can aid in the formulation of new hypotheses and research questions. Furthermore, people's perceptions and interpretations influence the way they respond to phenomena such as climate change and which options are regarded as appropriate. Our study also showed that this may differ significantly, even within a small geographic area, depending on factors such as local climatic differences and subsistence activities. Policies and projects aiming at promoting adaptation will only be relevant to local people if such differences are taken into account.

Perceptions and concerns of local people have sometimes been dismissed as irrelevant and superstitious by scientists and policy makers because they do not fit with their own world view. The Tibetan villagers in this study were able to accept different explanatory models (the knowledge they had acquired in school as contrasted with traditional Tibetan or Buddhist knowledge). It is our hope that scientists and policy makers equally will be able to accept the knowledge of the Tibetan villagers and other local peoples. Mutual respect is indispensable to gain a better understanding of climate change and to tackle its many-facetted impacts.

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