The Impact of a Tourism Boom in an Environmentally-Sensitive Region: A Case Study of Ladakh (Kashmir, India)

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Abstract

Ladakh is an extremely arid and mountainous part of India which is located near the Chinese and Pakistani borders, and which environmentally is a very sensitive region. The steady growth in tourism, and especially the almost exponential rise in tourist numbers since 2010, has placed great burdens on the environment. Of particular concern is the increased demand for the use of the scarce water in the region, a problem which has been further exacerbated by the effects of climate change, but there are also significant problems associated with soil degradation, water pollution and waste disposal, as well as possible negative effects on the traditional society. Based on literature reviews, interviews conducted in Ladakh, and personal observations, this paper examines the various environmental concerns and the measures employed to mitigate them, and suggests ways in which sustainable tourism can be implemented.

Key Words

environmental conservation, sustainable tourism, ecotourism, sustainable development

Contents

Introduction

The ancient kingdom of Ladakh forms a very isolated part of India which is situated to the north and east of Kashmir. (Until August 2019, Ladakh was officially in the state of Jammu and Kashmir, but in that month the Indian government announced that Ladakh would be designated instead as a federal territory under the direct control of the national government in Delhi). Ladakh is adjacent to the Chinese border and close to the Pakistani border, and consequently is a politically and militarily tense region. Culturally, however, Ladakhi culture is completely unrelated to mainstream Indian culture; the people traditionally have mostly followed the teachings of Tibetan Buddhism, although in the 2011 census the Muslim population had risen to 128,000 (Yaseen 2016). Ladakh's extremely remote and inaccessible location meant that it received little or no effect from development activities in other areas such as the Indus River valley, and this also shielded it from the devastating impact of external political events in Tibet proper, such as the effects of the Chinese Cultural Revolution. Little touched by tourism until recent decades, life continues in the traditional manner.

The effects of isolation were further enhanced by the fact that the mountainous and arid terrain is extremely inhospitable and the climate very harsh, with winter temperatures falling as low as minus 30C, and surrounding areas being even more frigid. In the past there were virtually no influxes of people from outside the region, especially during the period of near-isolation during the decades after the middle of the 20th century. According to the 2011 census, the population of the city of Leh was only 133,487 (Parvaiz 2018). Despite a major increase in population in recent times, the local population is still relatively small, with only approximately 275,000 in the whole of Ladakh; the majority of the people live in the cities of Leh (the capital) and Kargil (Yaseen 2016). However, because of security concerns related to the proximity of China and Pakistan, it has also been estimated that there are about 100,000 personnel in Leh associated with the military (Khandekhar 2017a: 4), although Rizvi (2012: 206) put the figure at about 40,000.

Although the figures mentioned above might suggest a fairly even Muslim-Buddhist population across Ladakh, in actual fact the situation is rather different. Towards the west, the population is predominantly Muslim (e.g. in Kargil, the main town in the area, the Muslim:Buddhist ratio is about 80: 20). In the east, though, the vast majority of the population follows Tibetan Buddhism (in Leh, Buddhists account for about 80%, whereas Muslims account for only 20%) (Tonyot Gyatso, Ladakhi guide/interpreter, personal communication).

Thus the Buddhist and Muslim communities tend to live apart, and they apparently seem not to particularly like each other. For example, when I needed to spend the night in Kargil (which is predominately Muslim), my driver and interpreter, who were both Buddhist, refused to stay overnight in the city. Instead, they drove to the nearest Buddhist community for the night, and then returned the next morning. This is actually not a new phenomenon. A few decades ago, Harvey (1983: 18) recounted how a Ladakhi Buddhist friend of his had said that whenever he hated someone, he prayed that they would later be reborn in Kargil.

Apart from tourism, Ladakh has had few options for acquiring cash (although it should be added that traditionally it was a barter economy); indeed, its only exports are dried apricots and pashm (a product

from goats that forms the basis of Kashmir's large shawl industry) (Rizvi 2012: 201–203). Tourism in the region eventually took off, though, and has continued to increase. However, with the increasing numbers of tourists visiting such an environmentally sensitive area, problems inevitably developed. This paper will examine the associated issues and attempt to assess what measures could be adopted to ameliorate the negative impacts.

Terrain and climate

The name "Ladakh" literally means "land of the high passes" (Wikipedia, date unknown, a). Indeed, the majority of the land is at an elevation of more than 3,000 metres, and rises much higher in the mountains and passes; the area is surrounded and bisected by some of the highest mountain ranges in the world. With the rarified air, the solar radiation is intense but temperatures are generally not so high; it has been said that Ladakh is the only place where a bareheaded person can sit in the sun with his feet in the shade and simultaneously suffer from both heat stroke and frostbite (Rizvi 2012: 42). The daily temperature range can be extreme; in summer in the capital city of Leh the high could be as much as 30C but then close to freezing at night. As mentioned, winter nights can be excruciatingly cold, with minimum temperatures as low as minus 30C.

Besides being at a high altitude, Ladakh also receives minimal rainfall as it is situated in the rain shadow area behind the Himalaya, the average precipitation amounting to only approximately 5 cm (Leh Ladakh Tourism, date unknown). (The implications of this will be discussed later). It has been described as the world's coldest (and highest-altitude) desert. In addition to this, the soil is not fertile. All of this combines to make living conditions extremely harsh.

One way in which this is manifested is in the traditional social structure of Ladakhi society; in common with other areas of Tibetan culture before the Chinese occupation of Tibet led to the banning of the practice there, in Ladakh there is still a custom of polyandry, the social system whereby one woman can have multiple husbands (Wikipedia, date unknown, b). At the same time, this was usually carried out on the basis of the monomarital principle, under which there is only one marriage per household in each generation (Rizvi 2012: 147). While appearing rather strange to outsiders, this structure has clear benefits for a society that exists in such an inhospitable environment with scarce resources. As the area of relatively fertile land is so limited, dividing the small landholdings for descendants would mean that the land would be split up into unsustainable small plots. Polyandry thus ensures that an adequate size of land is available for the descendants (Wikipedia, date unknown, b). The system enables a balance to be struck between fulfilling a family's need for labour in the fields, while avoiding the production of more children than the fields could support. Strictly speaking, the system was outlawed by the government of Jammu and Kashmir in the early 1940s, but this was mostly ignored in Ladakh; in recent years, though, it has declined gradually in central Ladakh, although it does survive, especially in the more remote villages and also in neighbouring Zanskar (Rizvi 2012: 148–149). However, even though polyandry may be quite common in Ladakh, other forms of marriage exist, even polygamy, which of course is the opposite arrangement to polyandry, and refers to the situation in which one man may have more than one wife. Norberg-Hodge (2016: 57) argues that this highly unusual arrangement is probably a means of flexibly adapting to life in a region where resources are so scarce.

Because of this, each family can choose the best living arrangements for their particular circumstances, which might include the amount of land available, and the number of offspring and potential partners etc.

The growth in tourism

For almost nine centuries from the middle of the 10th century, Ladakh was an independent and politically stable kingdom. This led to it being a crossroads on one of the ancient Silk Road routes (Jammu.com, date unknown). However, the area was in effect isolated from the middle of the 20th century until 1974 due to geopolitical and military tensions because it is adjacent to the Indian-Chinese border and because of its proximity to Pakistan. Indeed, the Indian authorities did not allow any tourists to enter the region until 1974.

Let us now consider why Ladakh is attractive to tourists. One of the key attractions for foreigners from the 1970s was probably the chance to experience the sights and sounds of Tibetan Buddhism, since the restrictions imposed by the Chinese government made it difficult to travel freely in Tibet. For example, to this day foreign tourists flock to see some of the major Buddhist festivals in what is often referred to as "Little Tibet", such as those held at the Hemis and Dakhthok Teschu monasteries (Wild Frontiers, date unknown, a). It must be added, though, that these festivals have equal attraction to the local population, with people from isolated villages walking for two days or more to witness the spectacle. Besides watching the spectacular masked dances etc., "the colourful crowd is itself part of the attraction, and their raucous merriment is infectious" (Wild Frontiers, date unknown, b: 8–9). Indeed, when observing the Hemis Festival myself, it was abundantly clear that the local people with their exuberance and friendliness were having an extremely good time, and observing them was as great a source of enjoyment as the supposedly main offerings of entertainment (Brian Harrison, personal observations).

The monasteries (usually referred to as gompas, which means "solitary places") and other parts of Ladakh's built heritage (such as the palace and old town in Leh) are also an attraction, although in 2007 the many years of neglect led to the New York-based World Monument Fund listing the old town as being one of the world's hundred most endangered sites. Fortunately, various NGOs have since taken measures to renovate the area (Rizvi 2012: 216).

Another attraction is the scenery, which is truly magnificent. In the highly acclaimed classic book "A Journey in Ladakh", Andrew Harvey attempts to describe the sense of awe that he felt when viewing the spectacular mountains: "phantasmagoria of stone, those vast wind-palaces of red and ochre and purple rock, those rock faces so unexpected and fantastical the eye could hardly believe them" and "sudden glimpses of ravines pierced and shattered by the light that broke down from the mountains" (Harvey 1983: 14).

Tourists are able to see the incredible mountain scenery with its snow-clad peaks, translucent lakes and barren terrain because many of the activities offered to tourists nowadays are outdoor-oriented, with perhaps the major activity being trekking (Wikipedia, date unknown, c). Ecotourism is a relatively new development, and on some of the more popular trekking routes (such as the Markha Valley) NGOs have encouraged the local population to upgrade their homes to accommodate trekkers, and women's

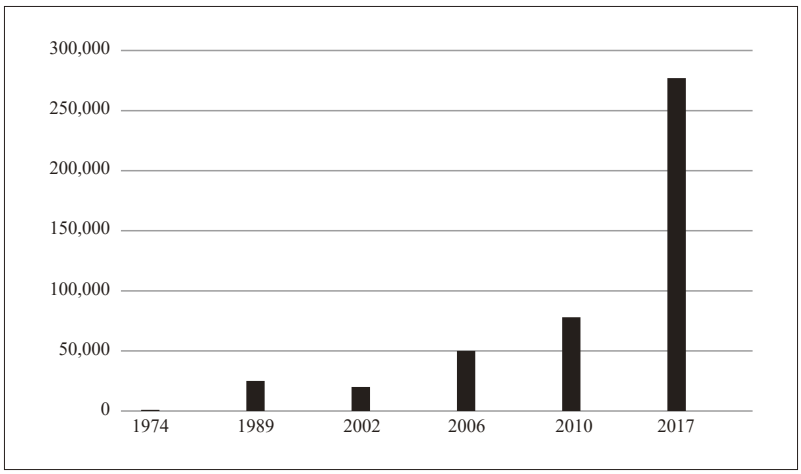

Figure 1 Increase in tourist numbers in Ladakh by year

self-help groups have established "parachute cafes" to sell local products with value added (mostly edible products or knitted apparel) (Rizvi 2012: 220).

It was not until 1974 that the Indian administration finally permitted tourism in Ladakh, but only 527 tourists arrived there that year (500 of whom were foreigners). Numbers did not increase much before 1978; tourism then only took off with the opening of an airport in Leh, the capital. Between 1974 and 1989 there was a steady growth in tourism, reaching a figure of about 25,000 people. The number of tourists then varied quite a bit between 8,000 and 20,000 until 2002, after which growth was exponential, rising to 50,000 in 2006, and continuing to rise thereafter (Widner 2012: 4). The dramatic growth that began occurring early in the present century can be seen clearly from Figure 1.

Most of the tourists until shortly after the turn of the century were foreigners, not Indians. However, all that changed partly because of increased prosperity among the Indian middle class but mostly because of the release and massive success of a Bollywood movie entitled "3 Idiots" which was filmed in Ladakh and released in December 2009. The domestic tourists were drawn to the spectacular scenery of Pangong Lake, which is a lake 120 kilometres long, of which 60% lies in China. Frequently up to 1,500 people now visit the lake every day, whereas previously only about 600 tourists used to visit in the entire summer (Hemalatha 2018b).

Following the popularity of "3 Idiots", domestic tourism exploded from the start of 2010, with the numbers of domestic visitors that year (55,685) far greater than that of foreigners (22,115) (Palkit 2017). One year after the release of the movie, the number of tourists going to Ladakh increased by nearly 300%, which put a tremendous strain on the region's infrastructure (Hemalatha 2018b). In addition, Hemalatha laments that many of the tourists are not sensitive to the environment, resulting in many plastic bottles etc. being merely thrown away. The various problems were exacerbated by the fact that most tourism is concentrated into the relatively short summer. This spurred over 4,000 volunteers in the Women's Alliance of Ladakh to campaign against the use of plastic bags, with the result that the national government of India pledged in June 2018 to stop all single-use plastic products in the whole country by 2022. Action has taken place more quickly in Ladakh, though, with the local government for

Jammu and Kashmir (where Ladakh is located) banning plastic bags in January 2018; offenders have to pay a fine of 5,000 rupees (about $73) or face up to one month in jail, or both (Thomson Reuters Foundation 2018). Unfortunately, the problem of plastic is not restricted to just plastic bags. It has been estimated that every day an incredible 30,000 plastic water bottles are discarded in Leh, causing a serious waste disposal problem (Dolma 2017). With this situation being replicated in many parts of the world, various adventure travel companies are encouraging travellers to carry their own filtration systems and use local tap water e.g. Wild Frontiers (Wild Frontiers, date unknown).

The trend of tourist numbers increasing has continued, with an annual growth rate of 30% between 2014 and 2017 (Palkit 2017). By 2016, the total number of tourists had risen to 235,482 (Khandekar 2017a: 2), with the vast majority accounted for by Indians (Wikipedia 2017). By the following year, this had shot up again to a total of about 277,000 (Wangchuk 2018). The enormous difficulties that this poses can easily be comprehended when it is realized that this is greater than the native population in the whole of Ladakh (274,000). Just between 2015 and 2017, domestic arrivals went up by 43% and foreign tourists by 28% (Goswami 2018: 2). The ranking of foreign tourists over the years 2014–2017 by nationality was French, Israeli and British. The only Asian countries in the top ten were Thailand and Japan (the latter having 6,134 arrivals). In order to accommodate the high numbers of tourists, there has also been a significant increase in the number of hotels and guesthouses constructed; despite there only being 24 hotels in Ladakh in the 1980s (Khandekhar 2017b: 2), as of November 2017, the number stood at 826, with these offering 13,732 beds (Hemalatha 2018b). Another estimate puts the total of hotels and guest houses over 1,050 – an almost unbelievably high figure when compared to the fact that in the 2011 census Leh had only about 4,300 households (Khandekekar 2017a: 3). Surprisingly, the whole of the hospitality industry is based on local people, whether it is a family adding one or two rooms to their house to accommodate paying guests or a local entrepreneur constructing a hotel (although many staff are hired from outside, especially Nepal). This may be because following partition several decades ago, the Indian constitution stated that only permanent residents would be permitted to own or buy property in the state of Jammu and Kashmir (which includes Ladakh), in order to preserve Jammu & Kashmir as the only Muslim-majority state in the country. (In the summer of 2019, though, the national government rescinded this provision in the constitution, and future repercussions are difficult to predict) (The Guardian 2019a). The investment in tourist accommodation is considerable, particularly when it is realized that every component of the structures must be transported in from outside the region (Rizvi 2012: 219).

Although numerous seminars, workshops and conferences have examined possible ways of minimizing the impact of tourism, and despite great efforts to involve all stakeholders so that the degradation of the natural environment can be limited, Rizvi (2012: 56–57) laments that the government authorities and private operators tend to unthinkingly ignore proposals that might lead to a reduction in profits. This has led to calls to limit the number of tourists to the region, spurred by the recent huge increase in domestic tourists (Parvaiz 2018).

One of the most serious problems associated with the boom in tourism is the greatly increased demand for water, with some large hotels using as much as 5,000 litres of water per day, which has major consequences for such an arid area (Hemalatha 2018b). Let us now consider this issue.

Problems associated with the shortage of water

As a high-altitude desert that receives a paltry annual rainfall of just 50mm, it is unsurprising that in Ladakh water is a precious commodity and that water shortages can be serious. Rivers do exist in the general region, but these flow at lower altitudes and therefore their water cannot be used by the majority of farmers. Although it might at first seem rather perverse, when visiting Ladakh, I was told that in times of drought the local people pray not for rain but for sunshine. That is because the main source of water is not precipitation but the melting of the snows and glaciers – which occurs because of the strong solar radiation and not higher temperatures (Brian Harrison, personal observation). Only 20% of the farmers in Ladakh are able to use river water for irrigation; for the other 80%, the only source of water for irrigation is glacier melt (Village Square 2017). Unfortunately, the weather data for Leh during the period 1973–2008 revealed an alarming drop in the amount of the winter precipitation that sustains the glaciers, with glaciologists also noting a declining area of high-altitude permafrost which acts as an additional water-storage system (Rizvi 2012: 39).

The demand for water in Leh is increasing at an alarming rate. In the city in 2009 over 1.5 million litres of groundwater were supplied each day during the summer months; however, it was predicted that the figure for 2019 would soar to 6 million litres per day (LEDeG, date unknown). Furthermore, those figures do not include the quantities of water pumped out by the many private borewells. This is a very serious matter since 90% of the people in Leh rely on groundwater for drinking and not streams.

Having lived in such an environment for a long period of time, Ladakhis have devised ways of conserving water that are in harmony with nature. However, as mentioned, with the great increase in tourist numbers the demand for water has soared. Making the situation far worse is the fact that the tourists use far more water per head than the local people. The Ladakh Ecological Development Group (LEDeG) notes that for drinking, washing and cooking, the average American uses 400 litres of water each day, while the average European uses 200 litres; in comparison, the average person in the developing world uses only 10 litres per day for the same things (LEDeG date unknown). On average, Ladakhis use an average of 21 litres of water per day, whereas tourists consume as much as 75 litres (Khandekhar 2017a: 3). Those figures are for summer, but in winter Ladakhis use even less water – only about 10–12 litres (Goswami 2018: 2). It has been estimated that almost 75% of people in and around Leh run either a hotel or guesthouse from their property; naturally, this means that it is necessary to have access to water 24 hours a day, 7 days a week (Khandekhar 2017a: 2, 3). The problem has been further exacerbated by the fact that some local people have installed modern sanitation facilities in their homes, thus using a greatly increased quantity of water (Wangchuk 2018: 3). In addition, the hotter weather is forcing people to increase the frequency at which they have baths (Goswami 2018: 3).

This all means that for the first time ever, Ladakhis have had to deal with severe water shortages. In order to overcome the situation, hotel owners began to indiscriminately dig borewells; with the lack of legislation and regulatory systems to restrict this activity, the groundwater table has declined considerably (Shobha 2009). Even today, the public health engineering department lacks the power to take action against groundwater extraction, even though such activities could have a serious effect on the springs which the population depends on and which are necessary for agriculture (Khandekhar 2017b:

5). However, due to awareness of the problem by the Ladakh Autonomous Hill Development Council (LAHDC), the public health department and local people, some action has indeed taken place. In 2014 the central government implemented the Urban Infrastructure Scheme for Small and Medium Towns, under which new reservoirs will be built, more durable pipes laid, and a piped sewage system constructed (Khandekhar 2017b: 6, 7).

The water shortage has become even more acute in recent years. In the years between 2013 and 2017 the annual precipitation had an annual deficit of between 50% and 80% for four consecutive years; indeed, in 2016, the precipitation amounted to a mere 20% of normal. The situation became so bad in the early summer of 2018 that Leh, the largest town in the region, had to initiate water rationing for two hours every morning and evening. Reports spoke of taps and borewells running dry (Wangchuk 2018: 1–3).

Temperatures have been increasing remorselessly. Although the rest of India registered a 1 degree temperature increase between 1973 and 2008, in Ladakh the rise was far greater – a huge 3 degrees. Perhaps not surprisingly this warming has led to glaciers retreating, with a 21% decrease in glacial area in the western Himalaya. One specific example is the Khardong La; formerly a huge glacier, by 2018 it had virtually disappeared (Parvaiz 2018). Besides the resultant water shortage, there are worries that if the trend continues and the glaciers begin to disappear, there will be the danger of potentially fatal flash floods and glacial lake outburst floods (Wangchuk 2018: 1–3). Indeed, there have already been devastating flash floods destroying villages in the past few years, as I myself witnessed when driving close to the sites that were swept away, leaving only rubble. Local Ladakhis have also noticed that the heavy snows are now falling later (in late January and February), and that spring arrives earlier (by March); this poses a dual threat – first, there is an increased risk of avalanches or flooding, and secondly, it could lead to droughts in the following years. Since not enough of the glaciers freeze before spring, it quickens the rate at which they recede (Wangchuk 2018: 2).

The water shortage problem has also become acute for the agricultural sector. As an example, let us consider the example of Nang, which is a village with a population of 334 (according to the 2011 census) which is located at an altitude of 3,780 metres and is about 30 kilometres outside the city of Leh. There is no permanent glacier there, and the perennial stream and natural springs do not provide anywhere enough water to fulfill the needs of the local farmers (Samten Choephel 2017). In 2016, the amount of water available for irrigation in Nang dropped by nearly 50%, leading to a great reduction in the potato yield. For Ladakhi farmers with small landholdings, the losses incurred can be huge (Village Square 2017).

It is clearly evident that Ladakh is suffering greatly from the scarcity of water. As mentioned, the problems have unfortunately been significantly increased in recent years as a result of global warming. Ladakhis have traditionally obtained their water from the melting of glaciers and snow; however, due to the global warming, these glaciers are now retreating. Fortunately there are some local people who have come up with some innovative methods of addressing the worsening situation. In particular, a major contribution was made by a local civil engineer called Chewang Norphel, who came up with the idea of what has often been termed “artificial glaciers”, and which led to him acquiring the nickname “The Iceman of Ladakh”.

Artificial glaciers and ice stupas

It is said that Norphel's inspiration came originally when he was a child in Ladakh and noticed how water flowed out of a semi-frozen pipe and then froze on the ground just like a glacier (Economic Times 2016). In 1986 as an adult working in Leh, he was aware that the shortage of water was a problem for agriculture, with at least 80% of the population being farmers who grow barley and wheat. The problem of particular concern was that not enough water was available in April and May, which was the time that the farmers needed the water for sowing, because the glacial streams were still frozen and river water was not accessible. No crops are grown in Ladakh in winter due to the severe winters, and the natural glaciers, which are situated at a much higher altitude (more than 4,300 metres) and are 20–25 kilometres away from the villages, did not melt until after June (Economic Times 2016).

Remembering his childhood experiences, he devised a means of creating what came to be known as artificial glaciers. He blocked water by building an embankment; the water would then begin to freeze along the length of the embankment in late November or December, creating an artificial glacier. At the time of his proposals, however, he became a figure of ridicule, with people openly mocking him as being completely crazy. Nevertheless, he persevered with his ideas; after persuading local people to cooperate, his ideas proved successful and indeed later were widely imitated (Village Square 2017). The technique would involve diverting water in early winter from a stream near a village to a north-facing slope, with embankments holding the water in shallow pools. After freezing, the volume of stored water could be increased because of winter snowfall on the ice. Due to being at lower altitudes than the natural glaciers, the ice would melt earlier, thus providing water which could permit earlier sowing, and thus prolong the growing season. No less than nine such projects were constructed in the Leh district between 2005 and 2010 (Rizvi 2012: 215). The current total (2019) is fifteen, with more planned (Chewang Norphel, personal communication).

The scale of the artificial glaciers is surprisingly large. For instance, the artificial glacier that Norphel built in Phuktse at a height of about 4,300 metres (which is much lower than the natural glaciers) is 2.5 kilometres long, 1 metre high, and has 27 walls (Avard 2013). Construction of such large glaciers necessarily takes time. Even with more than ten people working on the project, a large artificial glacier can take 4 or 5 months to complete, and about 6 weeks are needed for a small one (Chewang Norphel, personal communication).

Norphel explained that at the beginning he had a lot of energy but not much money, but this was gradually reversed as the decades passed. A key year was 1997, when a scheme was launched whereby each of several villages was granted the sum of 25 lakhs for development (1 lakh in the Indian counting system is equal to 100,000 - so this meant that the total amount made available worked out at about 2.5 million rupees per village; at 2019 exchange rates this would be equivalent to approximately just over 4 million yen). Assistance was also forthcoming from various other sources, including the Indian Army (Chewang Norphel, personal communication). The situation is therefore quite different to neighbouring Kashmir, where the army is sometimes viewed as an occupying force; relations between the military and local population are very good in Ladakh, probably because their infrastructure projects etc. benefit the Ladakhis and because, in contrast to Kashmir, Ladakhis do not have dreams of attaining indepen-

dence (Chewang Norphel, personal communication).

Norphel's work later served as an inspiration to a mechanical engineer called Sonam Wangchuk, who had already become quite famous for his work as a problem solver, and indeed a Bollywood film based loosely on his life grossed a billion rupees in just its first four days after release (Safi 2017). Wangchuk devised a way to create large vertical so-called "ice stupas" that were able to store water for a much longer time than had been possible using Norphel's techniques. "Ice stupas" refers to ice towers or cones that resemble the shape of the local Buddhist religious structures (note: "stupa" is a term commonly used in English, although in many parts of the Himalaya, the structures are referred to as "chortens"). In these, stream water flows down a steep pipe, after which it flows vertically up a pipe at the end, and is then sprayed into the air, where it immediately freezes.

In spring, the ice then melts and serves as a source of water for the villagers. These structures can be made with little effort or cost in any location that experiences subzero temperatures (Icestupa.net, date unknown). Wangchuk's success in developing these eventually led to him receiving a prestigious innovation prize worth £80,000 in December 2016 (Safi 2017).

The average height of the stupas is 35 to 40 metres; these can store up to 16,000 cubic litres of water, which is enough to irrigate 10 hectares of land (Pareek 2014). However, on occasions, the height can reach 50 metres (NHK 2018). Within two months of beginning a major project, Wangchuk succeeded in building an ice stupa the size of a two-story building that was capable of storing about 150,000 litres of water (Pareek 2014). He had realized that by reducing the area exposed to the sun and wind, it would be possible to store the ice in the villages themselves, instead of requiring the rather reluctant workers to climb to high altitudes, which had previously been the case. He achieved this by constructing ice cones vertically towards the sun; the reduced surface area that was thus exposed to the sun meant that the ice would melt much more slowly and provide water over a longer period.

Perhaps rather surprisingly, it is not necessary to use electricity to pump the water to a higher level. In order for the water to reach the top of the vertical stupa, it is only necessary to have the pipe joined to a higher upstream point, which means that the water will naturally maintain its level. The water which melts from the tip of the stupa will naturally flow downwards, at which point it will freeze due to the action of the cold wind, thus increasing the size of the stupa (Pareek 2014). Wangchok explained that the key requirement is that the water "has to be cool enough that it freezes as it gets in touch with the outside air, and at the same time, it should be warm enough that it does not freeze in the pipe itself" (Pareek 2014).

This is achieved by keeping the water in a liquid state while inside the pipe, but then having it instantaneously converted into ice after emerging from the end of the pipe. The successful outcome is achieved by a combination of first cladding the pipe to provide insulation from the bitter external temperature and utilizing the downward pressure from the steep pipe to maintain a constant flow of water, which then freezes instantaneously when it emerges from the pipe and comes into contact with the frigid air (Tonyot Gyatso, Ladakhi guide/interpreter, personal communication).

Other environmental problems associated with tourism in Ladakh

a) Soil degradation

As mentioned earlier, one of the main tourist activities in Ladakh is trekking. This involves walking along the trails made by local people, which are naturally dry and dusty. If such trails are not maintained properly, they can be easily eroded, especially when there is precipitation. This may lead to people widening the paths or seeking alternative routes, again worsening the problem (these problems are of course not restricted to Ladakh; they have been observed in various other regions of the world).

Unfortunately, soil degradation in Ladakh is made worse by such activities as off-road driving (e.g. in the popular area of Changthang in south-eastern Ladakh) and the impact of pack animals grazing (trekking groups often use large numbers of ponies or donkeys). Indeed, studies have shown a strong correlation between the intensity of the various trekking activities and the state of the soil (Widner 2012: 5, 6).

One countermeasure that has been introduced in agricultural locations is government encouragement for the planting of vegetation such as seabuckthorn, a low shrub which has a far-ranging root system that has excellent potential for water- and soil-conservation, as well as being an appropriate source of fuel (Rizvi 2012: 99).

b) Water pollution

Due to the serious lack of rainfall in Ladakh, traditional toilets in Ladakh were waterless; in addition to saving water, this allowed the manure to be used for soil fertilization (Widner 2012: 6). However, as outsiders began to flock to the region, many hotels were built and used flush toilets out of consideration for tourists' sensibilities. Unfortunately, this led to the twin problems of wasting precious fresh water and resulting in water pollution since Ladakh has no reliable sewage and waste-water treatment systems.

Trekkers are also causing water pollution either through carelessness or unhygienic habits. In the past, streams were kept in good condition because local people regarded them highly as a consequence of their religious beliefs, in which any act of pollution was viewed as a sin. For example, whereas Ladakhis would take water for washing from a stream using a basin, trekkers often have a bath directly in the stream.

Young Ladakhis are taught to be very careful about water use, including the fact that they must never use soap near a spring because of the pollution that would result. They would learn to not even wash their hands in running water, but to first remove the water from a stream and then use it (Chewang Norphel, personal communication).

There is thus a reduction in both the quantity and quality of available water. Perhaps not unexpectedly, the worsening of hygiene has been linked to the recorded increase in water-borne diseases and intestinal tract infections (Widner 2012: 6). Norphel stated that the pollution situation now is quite bad (Chewang Norphel, personal communication).

c) Waste disposal

As previously mentioned, many tourists merely discard waste such as plastic bottles. (Hemalatha 2018b) This seems to occur in many places; such spoiling of the natural beauty of the area also lessens the enjoyment experienced by subsequent visitors. In addition, though, are the possible polluting effects of the discarded items on surface- and ground-water.

Such behaviour also occurs in the wilderness areas where people should be especially eco-conscious. For example, members of the All Ladakh Tour Operators' Association were shocked by the scattered rubbish (including poly bags full of human waste) that they found lying by the side of the famous Chadar trekking route along the frozen Zanskar river in 2014 (Khandekhar 2017a: 3, 4).

Widner (2012: 7) quotes research carried out in another famous location for trekkers (the Everest region of Nepal) which revealed that a group of 15 trekkers generates 15 kilograms of non-biodegradable, non-combustible waste during a 10–day trek. He continues by arguing that similar figures probably also apply to Ladakh. He also points out that instead of the previous traditional use of only natural materials, modernization has brought about the import of a large quantity of less durable or heavily packaged consumption items, despite the inability to adequately treat such waste in Ladakh.

Exacerbating the situation is the fact that at the high altitudes that exist in Ladakh, the ecosystem is very different to the plains which many of the domestic tourists are used to. Specifically, according to an article published by the Mongabay-India environmental science and conservation news service, since temperatures are below zero for much of the year, organic waste can remain undecomposed for millennia and can infiltrate water sources, thus causing a further deterioration in water quality (Hemalatha 2018a: 8, 9).

In recent years, around the world there has been increasing awareness of the problems posed by the excessive use of plastics. Certainly, in Ladakh people (and especially the environmentally-conscious monks) seem to be fully aware of this. At the previously-mentioned major festival at the Hemis monastery in 2019, there were signs proclaiming that it was a "No plastic zone" and a "Waste-free festival". Indeed, there were no discarded plastic bottles to be seen, and there were special containers for uneaten food (Brian Harrison, personal observations).

d) Social effects influencing the environment

The staggering increase in tourist numbers (the number in 2017 was more than 10 times the number in 2002) certainly impacts the local population. The boom has definitely improved the material quality of life for Leh residents (for example, they can eat better vegetables and wear better clothes) but at the same time can threaten the local culture and traditional society (Thomas 2016). As Rizvi states (2012: 192), in order to be sustainable in such a delicate environment, development needs to be based on local resources, local knowledge and perceptions (emphasizing self-reliance), and to take into account factors such as pre-existing social and work patterns. Fortunately, the Leh Autonomous Hill Development Council was fully aware of these important factors. A discussion of the pros and cons of development and the accompanying social effects are beyond the scope of this paper, but it is important to note the effect that the social changes can have on the environment. For a fuller discussion of the important topic of social effects of development, and specifically how it affects the situation and society in Ladakh,

the reader is directed to the classic book "Ancient Futures" by Helena Norberg-Hodge; she describes how Ladakhis began to look down on their own culture when confronted with the apparent superiority of Western culture, but then how this could be counteracted by activities such as her "Learning from Ladakh" programme (as a result of which local people realise how many Westerners feel they have much to learn from the Ladakhi way of life) and the implementation of so-called "reality tours" in which Ladakhis are taken to the West and can see the myriad of problems as well as the successes, with many of the participants then returning to Ladakh and taking leading roles in their society, resulting in a new-found pride in their culture (Norberg-Hodge 2016).

Traditionally, over 85% of the population of Ladakh were involved with agriculture (Widner 2012: 8). The rise in tourism offered many opportunities to local people, especially younger people, who could earn substantially more cash by performing tourist-related jobs than by working in the fields, possibly as much as ten times the amount, as well as having to not work so hard (Chewang Norphel, personal communication). Unfortunately, the main tourist season overlaps with the harvest season, which results in the villages facing a manpower shortage at this important time of the year. Furthermore, peasants can earn more by renting out horses for trekking parties than by using them on their fields. This could mean that agricultural use of the land could decrease, and the resulting lack of care for the environment might create further problems such as increased erosion. Indeed, climate change has already inflicted damage; the normally water-starved region experienced unprecedented sudden and heavy downpours in 2010 which resulted in floods that swept away soil and caused many casualties (Widner 2012: 11). Then, as mentioned earlier, Ladakh suffered a number of years with rainfall amounts that were exceptionally low, even for this region (Wangchuk 2018: 1–3).

As far as the future is concerned, the numbers of farmers may well decrease further. Formerly the emphasis in agricultural communities was to train the young in farming techniques, but nowadays the first priority has switched to education, and money has acquired an importance that did not previously exist. This is having a spillover effect on the society. In the past, people in a village had a rotational system whereby everyone would help everybody else in turn. But gradually the cooperative system has begun to break down (Chewang Norphel, personal communication).

Indeed, tourism had begun to have an effect on the local society even by the early 1980s. After tourists were first allowed to visit Ladakh in 1974, numbers only grew relatively slowly, but nevertheless Harvey (1983: 49) relates how the wife of a hotel owner told him that although when she was young every family would send a child to be a Buddhist monk, by the start of the 1980s "every family was wanting their child to be a tourist guide".

In the last decade a new climate-related threat has also increased the problems of agriculture. Beginning in approximately 2013, locusts were first observed by Changpa nomads near the Chinese border, with the phenomenon blamed on changed climatic conditions in China. Since then, some areas have been infested with locusts, with 80% of crops and 70% of pasturelands being devoured. Although pesticides can alleviate the problem, there is considerable resistance to this by local people, who as Buddhists refuse to use the sprays out of religious convictions against killing, and also by environmentalists, who are worried about the possible excessive use of pesticides in what is a rare habitat of migratory and endangered birds (DownToEarth 2015).

Prospects for future tourism in Ladakh and Zanskar

The prospects for tourism in the various parts of Ladakh vary with the region. Let us now consider some of these.

a) Leh and vicinity

Leh has long been the main base of tourism in the region. Most visitors spend a day or two in Leh purely for acclimatization to the high altitude, and this often includes leisurely visits to the nearby attractions (e.g. Thiksey monastery, Shey Palace, Hemis monastery, etc.). The continuing increase in tourist numbers thus implies that even more visitors may arrive in Ladakh. Certainly with the ongoing construction of accommodation facilities, there is certainly the expectation of greater tourist numbers, although this raises questions about how sustainable such growth might be.

b) Nubra valley

Traditionally, the Nubra valley has been rather isolated since the journey there required visitors to ascend to the high Khardung La pass; the altitude is variously given officially on signboards at the pass as 18,380 feet (5,602 metres) or 17,982 feet (5,481 metres). (Brian Harrison, personal observations) However, there seems to be a consensus that the latter (lower) altitude is probably the correct value. Until relatively recent times, the route was unpaved and arduous. There were also restrictions due to the vicinity to the Pakistani border. Indeed, this formed part of the route to the Siachen Glacier, which acquired the status of "the highest battlefield in the world" due to armed clashes between India and Pakistan.

However, this situation ironically led to the opening of the region. Because of the militarily strategic importance of the area, the Indian Army upgraded the route so they could transport men and machines to the front line more easily, and most (but not all) of the road is now paved. Later, the government eased restrictions on tourists going to Nubra, which is now gearing up for an increase in tourism because of attractions such as the Diskit monastery, with its huge statue of the Maitreya Buddha and the existence nearby of Bactrian camels. Some of the villages are indeed now experiencing a building boom for guesthouses.

Nevertheless, there are worries about these developments. Although the local residents clearly look forward to the greater income that tourism will provide, there are worries about matters such as water. The villages currently receive good drinking-quality water from the streams and are careful to preserve this; but there are clearly concerns about how ignorant tourists might attempt to wash clothes or their bodies in the water, leading to potential pollution problems (thus rendering the water undrinkable). In a number of places, the residents have erected signboards warning visitors how they need to behave (Brian Harrison, personal observation).

As mentioned, one attraction of the valley is the presence of a number of Bactrian (i.e. two-humped) camels, and in particular the possibility of having a camel ride, an activity that seems to exclusively appeal to the domestic tourists. I was told that local operators are worried, however, because an NGO has gone to court to ban the practice, claiming that it is a form of animal cruelty. The local population

are fighting the lawsuit, arguing that they badly need the income the camel rides brings in (Tonyot Gyatso, personal communication).

Despite the potential difficulties, though, it seems likely that tourism to the Nubra valley will indeed increase further.

c) Zanskar

Zanskar was actually an old independent kingdom, but today often seems to be regarded by many as part of Ladakh, even though the local residents definitely consider themselves to be different to the Ladakhis of the Indus valley.

To reach Zanskar, it is necessary to first travel to the town of Kargil, the second largest town in Ladakh, which is situated on the main road approximately midway between Leh and Srinagar (the capital of Kashmir). There is then a beautiful drive along the paved Kargil valley before climbing into the mountains of the main Zanskar valley; from there on, the journey involves several hours of driving along the extremely bumpy and often narrow dirt road in the direction of the distant town of Padum, the capital of Zanskar. This is the only route open to motorized traffic, but the difficulties of the journey do not deter the many trucks plying the spectacular route (Brian Harrison, personal observation).

The hardships of the journey mean that only a few tourists have tended to visit the region; also, over many years the tourists consisted mainly of trekkers. There are few places for visitors to stay, and those that do often stay in a tented camp just below the picturesque monastery of Rangdum, which is situated on a small hill in a spectacular location surrounded by high mountains in one of the most extreme and isolated parts of the Suru valley. Visitors would be attracted by the magnificence of the scenery, the welcoming and beautiful monastery, and the charming Buddhist villages that are dotted around (Brian Harrison, personal observations).

It is thus not surprising that even today very few tourists venture to such a remote place. However, there are attempts beginning to bring in more visitors and therefore benefit the residents of this extremely poor area. For instance, I was told by Chhmet, a resident of the small village of Shakar Korpa (located a few kilometres before Rangdum monastery) that in 2017 an NGO constructed some solar panels in the village, with each household receiving a total of six lightbulbs. This apparently transformed the lives of the residents, with a small amount of electricity becoming available. This in turn led to hopes that in the future tourists might be attracted by the possibility of homestays in the village whereby the visitors would be able to gain the valuable experience of seeing how life is lived there, which is still in the traditional manner. In order not to cause disruption to the small and tight local community, visitors would be allocated in rotation to different houses to make sure that all villagers benefited equally from the proposed arrangement (Chhmet, personal communication). Perhaps surprisingly, the residents are not worried about the potential difficulty in communication (the local people speak Ladakhi rather than Hindi, and cannot speak English), convinced that gestures and goodwill would be enough. Certainly my experience with these very friendly people, who are generous despite their considerable poverty, suggests that they may be successful, although the scale of changes might be rather small.

In the future, though, the changes might be accelerated due to plans to construct a direct road from

Padum to Leh. Upon completion, the journey would be reduced from 2 or 3 days to a mere 6 hours, thus potentially opening up the area to more tourism (Chhmet, personal communication).

Discussion

Ladakh is an extremely arid region that is extremely susceptible to environmental damage. All the problems, from water scarcity to waste disposal to erosion, are rapidly becoming worse due to the very rapid growth of the tourist industry. Although acknowledging the economic benefits of increased tourist numbers, David Molden (director of the Internal Centre for Integrated Mountain Development) notes the difficulty of finding an acceptable balance between the promotion of tourism and the need to protect the environment (Khandekhar 2017a: 5). Nevertheless, there are some practical countermeasures that can be adopted in order to mitigate the situation.

One reason for the increase in water usage has been the introduction of non-traditional flush toilets in hotels. Tourists familiar with Western practices may squirm at the thought of using toilets constructed above cess pits, so a possible compromise might be to encourage the owners of accommodation to install dry compost toilets. I have personally used such toilets when travelling off the beaten path in West Africa, and found them quite acceptable. For a few years, there have been calls from local people to encourage tourists to use dry toilets (Times of India 2016). It is also surely necessary for the local authorities to enact greater regulation over the construction and operating facilities of the rapidly expanding number of hotels and guesthouses (especially borehole use), and (as mentioned) encouraging tourists to accept traditional practices of using dry compost toilets (Wangchuk 2018: 4).

It has been pointed out that tourists tend to use considerable quantities of water for showers etc. A local organization encourages them to make do with lesser amounts e.g. by showering less often or by using buckets. In addition, they should wash clothes in bulk (preferably using environmentally-friendly cleaning products) (LEDeG, date unknown).

An additional approach, which has indeed been acted on, is to encourage people to stay with local families – which would naturally result in water-saving behavior. Surya Ramachandran, a naturalist who operates a homestay in Ladakh, has urged tourists to forget creature comforts and stay with local families that run homestays, not just to experience local culture and lifestyle, but also in order to save on electricity and water. In addition, he argues for greater regulation of tourist numbers and stricter enforcement of the handling of solid waste (Hemalatha 2018a: 6).

With regard to actions such as throwing away waste at the roadside etc., surely it is necessary to take action to educate tourists. A number of Western travel companies (especially those providing trips to more adventurous destinations) have indeed made attempts to educate clients in general. However, it can be argued that in addition to this, they should provide their clients with very specific guidance about measures to be taken when visiting environmentally vulnerable locations. From comments in the literature, complaints have especially been levied against domestic travellers in Ladakh, who probably receive little or no advice about what constitutes acceptable behaviour. It therefore may be a good idea for the government to provide written advice to all tourists who arrive at the airport in Leh (the main gateway for travellers to enter Ladakh).

While I was in the area, more than one guide confided that they were worried that Ladakh might

follow in the footsteps of Shimla (formerly spelled "Simla"). During the period of British rule in India, in 1864 the British declared Shimla to be the summer capital of the country so that they might escape the searing heat of the Indian plains and be in a more pleasant climate (Wikipedia, date unknown, d). In more recent times, especially from the 1960s and 1970s, Shimla has attracted large numbers of foreign tourists due to the climate, nature and relaxing surroundings. However, later, domestic Indian tourists began to flock to Shimla, and I was told that due to the numbers and noise, the tranquil atmosphere no longer existed and that gradually foreign tourists tended to shun Shimla altogether. The Ladakhi guides I spoke to expressed great concern that the same trend might develop in Ladakh, complaining that domestic travellers tended to ignore local customs and ways of behaviour, were not aware of environmental matters, and generally disturbed the peaceful atmosphere. I cannot vouch for whether these guides were accurate or not in their statements, but certainly they seemed to be in complete agreement with each other.

With respect to the widespread single use of plastic bottles of mineral water (with the bottles frequently being discarded by the roadside), a possible solution which is being considered by some travel companies is to encourage the use of reusable filtered water bottles e.g. the British adventure travel company Wild Frontiers, which has won awards for their ethical approach to travel and the environment, announced that they would continue to supply water in plastic bottles to their clients only until the end of 2018, and that from 2019 they would cease that practice and instead ask clients to use a tested and proven filtered water bottle whenever possible (Wild Frontiers 2018). Another possibility is that hotels put a large replaceable tank of mineral water in a public area of the hotel, thus allowing guests to fill up their reusable water bottles whenever needed. I personally found this to be common practice when I travelled through various countries in Central America, and the system seemed to work well.

It has been suggested that the airport in Leh should be expanded as a further increase in tourist numbers would provide a large boost to the local economy. However, it would surely be best to put any such expansion on hold until the current problems can be more adequately addressed. Indeed, it could be argued that in order to preserve both the environment and also local social conditions, it might be worth considering a temporary cap on the numbers of tourists visiting Ladakh; certainly, in another Himalayan kingdom (Bhutan) such an approach has been praised for both preserving Bhutan's rich environment as well as helping to ensure stability of the traditional society. A further example is that of Easter Island (also known as Rapa Nui), which is a remote Chilean island located 3,500 kilometres off the coast of South America. The island attracts many visitors because of its famous and mysterious *moai* statues, but its fragile environment is under threat due to the impact of the rising tourist numbers. To mitigate the situation, in July 2018 the government announced plans to immediately reduce the number of days tourists could stay on the island, and said they would consider a proposal to introduce a limit on the number of people allowed to visit Easter Island (Whitehead 2018).

This of course raises the question of whether such an approach might be practical. Travellers to Ladakh essentially are restricted to entry by one of three ways. Those who fly will arrive in Leh, and it would be easy to impose restrictions on flight and passenger numbers. The alternative method of travel involves road journeys, and there are only two possible routes. Tourists can arrive by road by travelling

either along the Manali-Leh highway, or by driving along the main road linking Srinagar in Kashmir to Leh via Kargil. (Due to the emergency declared in August 2019 following the national government's cancellation of Kashmir's special status, no non-residents are allowed to enter the area, and thus no tourists can travel between Srinagar and Kargil). Obviously it would be difficult to impose limits on entries, but it would be simple to impose an entry tax (and additionally to distribute leaflets instructing tourists on how to behave). Indeed, the All Ladakh Tour Operators Association has proposed that all tourists (both foreign and domestic) be subject to an environmental tax that should be used to promote sustainable tourism in the region and to protect the fragile ecology and vulnerable population (Khandekhar 2017b: 7).

The modern water shortage, as discussed earlier, existed before the explosion of the tourist industry and has been greatly exacerbated by climate change. For local farmers the innovative work carried out by first Norphel and later by Wangchuk has had a remarkable effect. The allocation of funds to expand the construction of artificial glaciers and ice stupas across Ladakh could make an incalculable contribution to the maintenance of agriculture in the region.

To conclude on a cautionary note, it would perhaps be advisable for Ladakhis to avoid an over-reliance on tourism, bearing in mind what happened in neighbouring Kashmir in the 1990s, which then had a thriving tourist trade. At that time, exploding tensions between India and Pakistan concerning sovereignty over the region, accompanied by violence from militants, led to tourists completely abandoning Kashmir, with the result that numerous local people lost their source of livelihood. Then in the summer of 2019 (literally only a few days after I left Kashmir) the alleged worsening security situation led to the Indian government ordering all non-residents to leave the region immediately and cutting all internet and phone communications. Several Western governments announced that their citizens should not visit the area for any reason. In retrospect it seems that the real reason for the order was to prepare for the Indian government's abolition of Kashmir's special status. The situation seems almost certain to deteriorate further, which has led to previously supportive local politicians such as Mehbooba Mufti (a former chief minister of Jammu and Kashmir) accusing India of an "illegal occupation" (Guardian, 2019a) and being an "occupational force" (Guardian, 2019b). These events will definitely have a devastating effect on tourism in the area for a considerable time to come. The tension, though, has specifically affected Muslim Kashmir, and although tourists can continue to visit Ladakh (Charlie Beringer, Wild Frontiers, personal communication) at present it is impossible to reliably predict the effect on Buddhist Ladakh, which is not directly involved in the conflict. As mentioned, one possibly positive note for Ladakhis is that the announcement that Ladakh would no longer be part of Jammu and Kashmir, but instead a separate entity as a federal territory under the direct control of the central government, could potentially limit any negative consequences of recent events on tourism in Ladakh (Guardian, 2019b). The formal division then took place at the end of October 2019 (Guardian 2019c).

Conclusion

In the last few decades the rapid growth of tourism in such an environmentally sensitive area, combined with the effects of climate change, has posed an extremely grave threat to the environment of Ladakh, and in particular to the availability of water. However, by expanding the innovative develop-

ment of artificial glaciers and ice stupas, it is likely that the problems of irrigation facing agriculture can be solved sufficiently for farmers to thrive. Sensible policies for combatting the problems caused by the increase in tourism have been suggested, such as the education of tourists about the environment, the collection of tourist taxes, the encouragement to change to compost toilets instead of using water-intensive flush toilets, and possibly a control over tourist numbers (either by restricting the total number of visitors or, if this is deemed impractical, then by imposing taxes). If such policies can be fully put into practice, the environmental problems of Ladakh may not disappear, but can probably be mitigated to an acceptable level.

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