

1st International Conference on Asian Highland Natural Resources Management, AsiaHiLand  
2015

## Changing Land Use and Water Management in a Ladakhi Village of Northern India

Shinya Takeda<sup>a\*</sup>, Takayoshi Yamaguchi<sup>b</sup>

<sup>a</sup>Graduate School of Asian and African Area Studies, Kyoto University, Kyoto 606-8501, Japan

<sup>b</sup>The National Institute for Agro-Environmental Sciences, Tsukuba 305-8604, Japan

### ABSTRACT

Focusing on agro-pastoralism and the change in farmland use by the highlanders in Ladakh, Domkhar valley in lower Ladakh was selected as the research site. Domkhar valley has a total population of 1,269 people and 193 households and is divided into three villages based on their locations: Domkhar Do (lower village, 3,000 to 3,100 meters altitude), Domkhar Barma (middle village, 3,400 to 3,500 meters altitude), and Domkhar Gonma (upper village, 3,600 to 4,000 meters altitude). There is a hamlet called Kuramric at the highest point of the upper village at 4,100 meters. The villagers release their livestock in the pastures in the U-shaped valley located above Kuramric. Barley is the main crop cultivated in all three villages. Wheat can be cultivated in the lower and middle villages, but not in the upper village. We created a list of households in the three villages in Domkhar valley before conducting interviews. We then created a map showing irrigation canals, the land ownership and usage of each household from the GeoEye-1 satellite images taken in September and November 2010. We elucidated the change in land use and water management based on this map of irrigation canals, land ownership and usage along with the interviews and on-site observations. For more than 30 years, Ladakhi people has been receiving government rations of cheap flour, rice, sugar, and petroleum in Ladakh where the Sino-Indian Border Conflict and the Indo-Pakistani War were fought. For this reason, their staple food has switched from barley to the rationed flour. The change in the livelihood of agro-pastoralism has brought about changes in the land use, but even in this case, the temperature constraint from the difference in altitude remains a major defining factor in the selection and introduction of cash crops.

© 2015 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the Faculty of Agriculture, Chiang Mai University

**Keywords:** Snow-fed streams irrigation; mountain oasis; agro-silvo-pastoralism; land use change; Ladakh

### 1. Introduction

Ladakh, located in northern India is a highland spreading in the riverhead region of the Indus River surrounded by the four major mountain ranges of Karakorum, Ladakh, Zaskar, and the Himalayas. The climate in this region is dry and cold, but there are green oases created by use of melted snow spotting the valley. Compared to an arid region at low altitude, the mountain oasis in Ladakh is located at a high altitude and is inherently cold. While it is too cold to farm at high altitude of over 4,000 meters above sea level, it is possible to grow barley in the lower altitude canyons. Still, these canyons receive an annual rainfall of about 100 to 150 millimeters, much less than the precipitation in the large pastures just below the glaciers, making growth of plants difficult. The melted snow

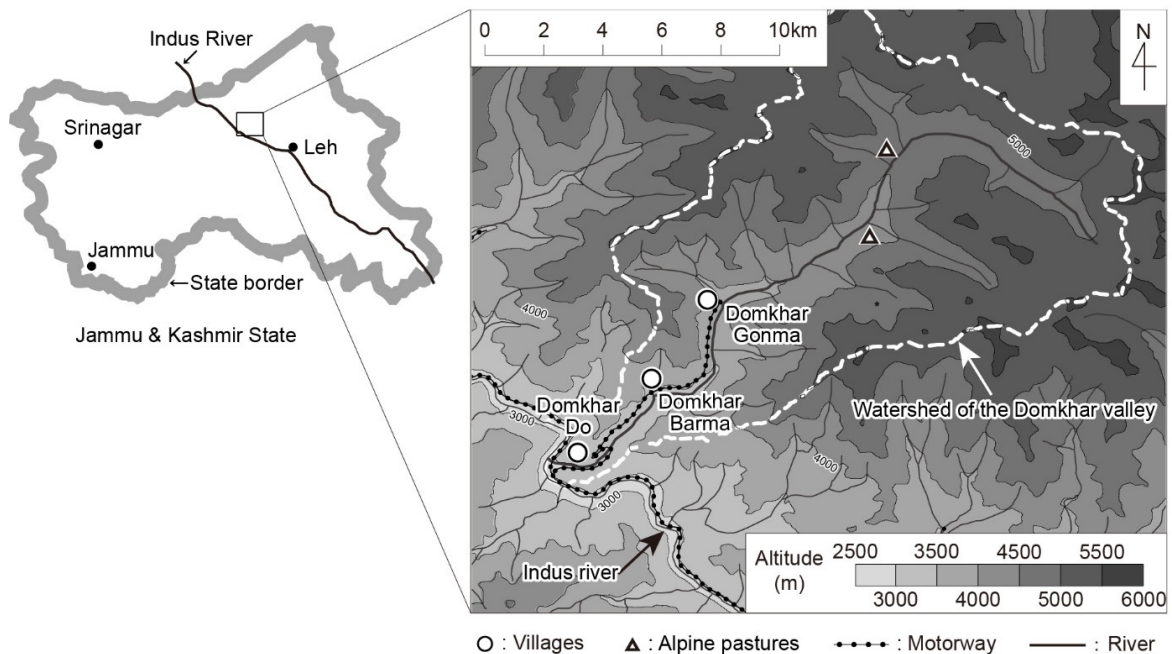
\* Corresponding author. Tel.: +81-75-753-7836 ; fax: +81-75-753-7834.  
E-mail address: [takeda@asafas.kyoto-u.ac.jp](mailto:takeda@asafas.kyoto-u.ac.jp)

from the high altitude glacier springs forth here and there in pastures and flows together to form a river with dry desert-like banks on either side of the valley. Only irrigated areas turn into green mountain oases.

Tibetan people inhabit this region and practice Buddhism. While Ladakh prospered as a way station for trade between central Asia and Tibet, the trade came to a halt because of the Sino-Indian Border Conflict in 1962 and the subsequent Indo-Pakistan War. After that, Ladakh's regional economy was supported by the Indian army stationed to secure the national border. In addition, the recent economic development in India has also brought about a great transformation in the conventional livelihood and land use. We have been focusing on agro-pastoralism and the change in farmland use by the highlanders in Ladakh in the research (Tsukihara 2009, Takeda 2014).

## 2. Research sites and methods

We selected Domkhar valley in lower Ladakh as the research site. It is about 25 kilometers long and covers an altitude difference of 2,000 meters as it originates from the glaciers down to the Indus River. Lateral moraine, parallel ridges of soil and rock debris deposited along the sides of a glacier, can be found at around 4,000 meters above sea level. There is a gentle U-shaped valley above the lateral moraine and a steep V-shaped canyon formed by erosion from the main river below the lateral moraine.



**Fig. 1.** Map of the Domkhar valley

Domkhar valley has a total population of 1,269 people and 193 households and is divided into three villages based on their locations: Domkhar Do (lower village, 3,000 to 3,100 meters altitude), Domkhar Barma (middle village, 3,400 to 3,500 meters altitude), and Domkhar Gonma (upper village, 3,600 to 4,000 meters altitude). There is a hamlet called Kuramric at the highest point of the upper village at 4,100 meters. The villagers release their livestock in the pastures in the U-shaped valley located above Kuramric.

We created a list of households in the three villages in Domkhar valley before conducting interviews. We then created a map showing the land ownership and usage of each household from the GeoEye-1 satellite images taken in September and November 2010. We elucidated the change in land use and agro-pastoralism based on this map of land ownership and usage along with the interviews and on-site observations.

### 3. Results and discussion

#### 3.1. Altitudinal distribution of cultivated plants

We visited Domkhar village in Ladakh for the first time in July 2008. We left from the central city of Leh in Ladakh at 3,650 meters altitude and traveled along the Indus River to enter Domkhar valley via the main river. There was a grove of apricot trees loaded with ripe apricots in Domkhar Do (lower village) located at the entrance of Domkhar valley. A villager told us that the apricot trees flower in the lower village first and then bloom sequentially up the valley. The altitude difference between the lower village and the upper village is 1,000 meters and the temperature difference between the two villages in the summer can go up to 10 °C. Thus, they grow different crops and trees according to the altitude.

Barley (*Hordeum vulgare*) is the main crop cultivated in all three villages. Wheat (*Triticum aestivum*) can be cultivated in the lower and middle villages, but not in the upper village. In the lower village, they also grow cash crops like turnips (*Brassica campestris*), tomatoes (*Lycopersicon esculentum*), carrots (*Daucus carota*), and other vegetables along with barley and wheat. It is also possible to double crop; they can plant buckwheat (*Fagopyrum esculentum*) and foxtail millet (*Setaria italica*) after barley is harvested. The lower village is also suitable for growing orchards and along with its neighbor Khalatse, has a high production of apricots (*Prunus armeniaca*). In the middle village, they can cultivate buckwheat, foxtail millet, broad beans (*Vicia faba*), and brown mustard (*Brassica juncea*), in addition to apricots. Crops that can be cultivated in the upper village are limited to barley, peas (*Pisum sativum*), and alfalfa (*Medicago sativa*).

There are Persian walnut and yulat poplar trees (*Populus nigra*) lining the lower village, but these trees can only thrive as high as the middle village. The trees planted in the upper village mostly and uniformly consist of dokchang willow trees (*Salix scleophylla*).

#### 3.2. Irrigation channels in the mountain oasis

Domkhar valley pours into the Indus River. In the winter, snow accumulates on the mountaintop where the valley originates. From spring through summer, the snow melts and nourishes the mountain oasis along the valley. The maximized use of water from melted snow is one of the mechanisms that had long supported agriculture not just in Domkhar, but also in Ladakh and throughout Cultural Tibet. We will next discuss this mechanism.

The water catchment area at the source of the valley is relatively large and has a fairly high water volume in the summer that there was once a plan to build a dam. There are 59 main irrigation channels set up throughout the valley (Photo 1). Willow trees and poplar trees are planted along the channels. In some places, the channels cross a smaller valley and bore through a vertical stone wall. There is a total of 246 hectares of irrigated farmland.



Photo 1. Primary irrigation channels in Kuramric, 4000m above sea level. August 2009.

In Ladakh, they generally appoint a person called chupon who is responsible for controlling irrigation water and coordinating people's interests, but such a person is not necessary in Domkhar where water is abundant and there are no water disputes.

One person from each household participates in the cleaning of the main irrigation channels on a particular day in March on the Tibetan calendar. A monk often appoints the date, but on some occasions, the villagers will consult the calendar and determine their own schedule. After the cleaning, they pass around an alcoholic beverage made of barley called chhang while they gather around the intake area and then run water through the channels. There is no chupon in Domkhar, but there is a person selected to prepare chhang.

While there is no practice of it in Domkhar, there is another irrigation method called khyags-chu (frozen water)" that is unique to Ladakh. They flood the fields at the end of fall and let the water-soaked soil freeze over the winter. They can begin plowing as soon as the fields start to melt in the spring. This method is often used in water deficient regions like Alchi and Saspul where people compete for water especially in the spring. It can also prevent soil dispersion from the strong winter winds in Tibet. This is a valuable knowledge in a region dealing with soil containing a large amount of loess that can easily be scattered.

At the highest village of Kuramric in the upper village (4,100 meters above sea level), we saw villagers sprinkle ashes over the snow-covered farmlands in March to promote snow melt.

They cannot store water in its liquid form unless they build a dam or a reservoir. Wittfogel focused on this special water characteristic and reasoned that "abundance of water creates technological challenges that can only be resolved through mass labor (Wittfogel 1957)." This is the hydraulic hypothesis, which theorizes that the masses mobilized for flood control and irrigation can lead to despotism so powerful that the masses mobilized for waterworks can then be mobilized for other collective efforts, such as building of the Great Wall of China.

In comparison, the scale of irrigation in Domkhar is so small that they only need a few households to build and maintain it. Furthermore, enough water is stored upstream without having to build a large-scale dam or a reservoir. The snow that had fallen on the mountains during the winter accumulates on the glacier and supplies water to the oasis as it melts when spring arrives each year. In some cases, the villagers flood the fields in the fall and allow it to freeze during the winter. As stated previously, people need a dam to store water that is liquid, but not when it is in a solid form as ice. The frigid condition is allowing the frozen field to function like a natural dam.

People in Domkhar modified the dry valley into a mountain oasis with the use of melted snow so that it became inhabitable. It also became a system that allowed them to skillfully utilize the cold climate. These irrigation channels seem to be indicative of the wisdom of the Domkhar people who effectively utilize nature instead of trying to go against it.

### 3.3. *Combined system of Agro-silvo-pastoralism*

The upper village in Domkhar includes smaller villages like Kuramric, which is located above the lateral moraine in the U-shaped valley. The lower slopes and the valley floor of the U-shaped valley are important grazing ground for livestock, such as yak, cattle, and yak-cattle hybrids. This is why households from the upper village as well as households from the lower and middle villages own farmlands in Kuramric. Yaks, cattle, and yak-cattle hybrids serve as a dairy cattle as well as a draft animal for farming and transportation. The herd of goats/sheep (raluk in the local language) is essential for manure production along with milk and wool.

The staple food of the Ladakhi people is the roasted barley flour called tsampa mixed with butter tea. The combination of pastoralism in the U-shaped valley upstream and irrigation agriculture in the farmlands midstream and downstream has supported their dietary life.

As for the land ownership in the three villages, most of the farmlands in the lower village are owned by the households from the lower village, while the upper village and Kuramric in particular has some mix of lands owned by households from the middle and lower villages. The households from the middle and lower villages living in the V-shaped valley in lower Domkhar have limited areas of flat farmlands and pastures for the conventional agro-pastoralism system. This is why they release their livestock in high altitude pastures above the upper village. They experience a shortage of pastures in midstream and downstream areas especially during the planting season, so the livestock is often entrusted with a herder in a pasture in the U-shaped valley upstream (Ikeda 2010, Hirata 2011). When the summer is over, the livestock returns to their respective villages. They feed on wheat straws and alfalfas during the winter. In early spring when they start running out of feed, they also feed

on willow barks.

There is very little rain in Domkhar valley midstream and upstream, but there are green pastures upstream and at the upper tributary of Domkhar valley where they enjoy plenty of alpine rainfall and snowfall. The U-shaped valley is suited for livestock grazing. The villagers utilized melted snow to transform a desert land along the river into an oasis abundant with crops and greeneries in regions midstream and downstream of the valley. Even the livestock manure is an important product for increasing agricultural productivity. The oasis in Domkhar valley is created by people by connecting the valley's natural resources using livestock and network of irrigation channels for melted snow from the glacier. There are fine details involved in this artificial work.

For example, the villagers collect topsoil from the farmland after barley or other crops have been harvested and make a pile beside the livestock pen or the outhouse. This work is called sachat (Photo 2). The collected topsoil is sandy, but has a slight mix of agricultural residue. After a person uses the outhouse, they can scoop some of this topsoil into the fecal matter to create human fertilizer. Farm work in early spring begins by applying manure found inside the livestock pen or human fertilizer stored in the outhouse to the farmlands. Since the soil in the valley is sandy, fertilizer made of livestock manure and human excrement have supported the agriculture in Domkhar.



Photo 2. sachat in Kuramric, 4000m above sea level. September 2011.

Tibetans in Domkhar valley are “not farmers, but agro-pastoral people... who take an integrated approach to agro-pastoralism with the small oasis as its foundation (Kawakita 1961).” We can tell from the land use in Domkhar that agriculture, pastoralism, and forestry are connected by the oases as they effectively capitalize on the difference in altitude.

For example, household R from the middle village of Barma owns Dokusa (summer hut) in the upper village of Gonma. Primarily, the wife is living in the hut alone for four months between May and August for farming. They own two strips of farmland next to the hut, but nothing is planted in one of the fields. They planted barley and peas (Shanma) in the other field, but it is covered with white flowers of a weed called Shichiment, because they have not kept up with the weeding. The elderly couple from household R is responsible for the farm work, although the neighbors help out with plowing. There is a labor exchange called besu and a volunteer service called milaku available and the elderly couple relies on the latter. The old wife heads back down to the middle village of Barma after the barley harvest. They have a daughter who used to help out with farming, but she became a school teacher. The lack of help in the fields has forced them to set aside the farmland. The couple currently owns two dzo (F-1 male yak-cattle hybrid), one dzomo (F-1 female yak-cattle hybrid), and five cattle. These animals are released in phu (high altitude pastures) and tended by baresu a herder from each household on a rotating schedule. In the past, the couple owned several dozens of goats/sheep, but the number is currently down to about 20. They use cattle and goats/sheep manure as fertilizer in the farms. They can minimize the use of chemical fertilizer since they use livestock manure and the area of farmland in use has decreased.

The combined agro-pastoralism has functioned well until now as they utilize the altitude difference through the

use of high altitude pastures, summer hut for farming, and manure, but there have been changes as witnessed from this case study. These changes include younger generation choosing non-agricultural careers, a decrease in the number of livestock (they are no longer needed for transportation with the development of roads and there are less herders as a result of education), and peas, formerly grown for personal consumption, are now being marketed as green peas (improved access to markets with the development of roads). We will continue to discuss these changes in the next chapter.

### 3.4. *Changes in livelihood structure and land use*

At one time, agriculture, pastoralism, and trade were the livelihoods that supported the village, but off-farm jobs have now become more common. For example, majority of the residents of the upper village with the harshest conditions (227 people out of 552 people from 82 households) live outside of the village for more than six months! out of the year. Moving to cities like Leh to attend high school and university, enlisting in the army, or working at the military post as a driver or a government employee has provided them with an opportunity to pursue off-farm jobs (Yamaguchi 2010).

By the summer of 2011, the roads have extended to the upper village of Chanchak in Domkhar. They were! starting to construct a road all the way to the uppermost village of Kuramric. They had electricity in the village and satellite TV set up in schools once the roads reached Chanchak. The children from the extremely secluded village of Chanchak receive preferential treatment from the Indian government who provides them with a heated dormitory at an advanced school in Khalatse if the children graduate elementary school and choose to pursue more education. This is a special deal offered only to the children living in villages with harsh conditions like Chanchak, Kuramric, Linsit, and Urugisu. After they advance to a school in Khalatse several hours' drive from the village, some will go on to enroll in university in Srinagar or Delhi. While the parents of these children complain about the school expenses, they appear to be very proud. However, there is no guarantee that these children will return to the village after they complete their higher education.

## 4. Conclusions

For more than 30 years, Ladakhi people has been receiving government rations of cheap flour, rice, sugar, and petroleum in Ladakh where the Sino-Indian Border Conflict and the Indo-Pakistani War were fought. For this reason, their staple food has switched from barley to the rationed flour. They purchase cheap rationed foods with their income from off-farm jobs, which generate significantly more income than their farming jobs. By now, the roads have reached the upper village and they do not need to rely on their livestock for transportation. These changes have not only led to a reduction of agro-pastoral livelihood system led by elderly people living in the village as a whole, but also to a decline in the complementarity of the elements of agro-pastoralism.

Presently, people are beginning to abandon their farmlands in the upper village due to unfavorable farming conditions, such as steep slopes and small areas. In the middle village, the villagers started planting Dokchang willow and Yulat poplar trees in some of the lands with unfavorable farming conditions. Almost all the farmlands in the lower village are in use, because they can grow cash crops like fruits and vegetables. However, the households living in the lower village have abandoned many of their farmlands in the middle and upper villages.

The change in the livelihood of agro-pastoralism has brought about changes in the land use, but even in this case, the temperature constraint from the difference in altitude remains a major defining factor in the selection and introduction of cash crops.

## Acknowledgements

This study was supported by a Grant-in-Aid of Research Institute of Humanity and Nature (3–4 FR): Human Life, Aging, and Disease in High-Altitude Environments: Physiomedical, Ecological and Cultural Adaptation in the Great “Highland Civilizations” (leader: Okumiya Kiyohito). We thank project members and Ladakh residents who participated in this survey.

## References

- Wittfogel, Karl A. *Oriental Despotism: A Comparative Study of Total Power*. Yale University Press, 1957
- Ikeda N. 2010. Economic Aspects of Pastoralism at the Present Day in Ladakh, India: A Case Study in Domkhar Village. *Himalayan Study Monographs* 11:91-105. (In Japanese with English summary)
- Kawakita, J. 1961. Some Ecological Observations in Nepal Himalaya: Torbo Ethnography, No.3. *The Japanese Journal of Ethnology*. 25(4), 197-238
- Takeda, S. 2014. Environmentology of Birth, Aging, Sickness, and Death from Highlands Perspectives. In *Aging, disease and health in the Himalayas and Tibet*, edited by Okumiya Kiyohito, pp181-201. Rubi Enterprise.
- Tsukihara T. 2009. Interdisciplinary Studies with Medical Science: an Ongoing Plan in Ladakh. *Himalayan Study Monographs* 10, 174-182. (In Japanese with English summary)
- Hirata M. 2011. Characteristics of Transhumance in Ladakh, Himalaya: Complex System among Agriculture, Pastoralism and Broad Trade. *Himalayan Study Monographs* 12, 40-59. (In Japanese with English summary)
- Yamaguchi T. 2010. Social Transition in a Ladakhi Village, northwestern India: The Relation between Man and Nature in the Mountainous Area. *Himalayan Study Monographs* 11, 78-90. (In Japanese with English summary)
- Yamaguchi T., Sonam Ngodup, Nose M., Takeda S. 2013. Land Use and its Transition in an Agro-Silvo-Pastoral System of a Ladkhi Village, Jammu & Kashmir, India. *Himalayan Study Monographs* 14, 102-113. (In Japanese with English summary)