Chapter 9
Water Harvesting Technologies and Management System in a Micro-watershed in Ladakh, India

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1. General

Ladakh constitutes the northern-most part of India. It is a high altitude region, the lowest point being 2,700 masl and some of the mountain peaks are over 7,000 metres high. Leh, the capital of Ladakh, is at an altitude of 3,500 m and there are villages as high as 4,500 masl.

Ladakh physically lies to the north of the Great Himalayan Range and south of the Karakoram Range. It is straddled by two other parallel ranges, the Zanskar and the Ladakh, in addition to the Great Himalayan and Karakoram ranges, all of them traversing roughly from south-east to northwest.

Ladakh is connected with other parts of India and the outside world by the 434km-long Srinagar-Leh road and 472km-long Manali - Leh road. The two roads remain open for traffic from June to October only. For the remaining seven months, no traffic is possible because of heavy snowfall over Zojila on the Srinagar-Leh road and over Rotang on the Manali – Leh road. During this period, the only available means of transportation between Ladakh and the outside world is by air.

Agriculture in Ladakh is completely dependent on irrigation and is spread over about 230 watersheds, big and small. The sources of water are rain, snowbanks, glaciers, springs, and marshes, depending on the location and size of the village. The larger villages (with fifty or more households) are generally situated on *tokpo* (streams) fed by snowbanks and/or glaciers located in the higher reaches of the catchment area. Smaller villages or hamlets (some as small as just one or two families) may depend on a spring only in addition to runoff from snowmelt or rain in the limited catchments above the villages. The size of the area irrigated in a watershed depends on two important factors (1) agricultural season and (2) availability of water.

The dates for sowing and harvesting are fixed by climatogical factors. These cannot be advanced or delayed without jeopardising the quality and quantity of crop yields. Advancing the sowing date may inhibit germination of seeds and any delay in sowing may

lead to a situation in which the crop may not mature at all because of low temperatures or even snowfall during late autumn.

Rather than the total quantity available, seasonality of water supplies restricts the irrigable area in a watershed. This is especially true of sizeable watersheds dependent on large snowbanks and/or glaciers. Generally the amount of water available in the *tokpo* when the first irrigation after sowing becomes imminent is critical. This is the time when the ambient temperature is not high enough to induce the melting of snow (not to speak of glaciers) in the higher reaches above the watershed but irrigation is indispensable for the welfare of the crop if it is to mature in time for a plentiful harvest. It can thus be concluded that the amount of water available in a *tokpo* during the first irrigation period generally limits the area that can be irrigated. All watersheds in Ladakh, except those fed by the Indus and its tributaries, have been developed by village communities to optimum capacity depending upon the minimum quantity of water available during the sowing season. Water that is seen going waste during the rest of the summer cannot be used given the limited resources of village communities. How to use the surplus water through an economically viable system is a challenge that modern planners and developers will have to meet in order to increase the area irrigated in any watershed.

2. SELECTION OF A WATERSHED FOR THE CASE STUDY

The selection of a watershed for the study proposed was finalised after going through a list of all the 200 and odd watersheds in the district. Given the limited period available for the study and vastness of the region, a short list of four was prepared. Details of the four watersheds are given in Table 9.1.

Table 9.1: **Description of watersheds studied**

S. No	Name	Area Irrigated(in *kanal[s]*)	Population 1981 Census	Source of Water for Irrigation	Orientation	Whether Village Share Wwater with Other Villages
1	2	3	4	5	6	7
1.	Alchi	77.0	557	Spring and snowmentl.	Northern aspect	No
2.	Phey	44.0	176	Local springs and *tokpo*	Southern aspect	Yes – village Phayang upstream has the prior right over the water of glacier/snow fed *tokpo*
3.	Stok	188.0	1,077	Glacier, snowbanks and springs	Northern aspect	No
4.	Sakti – Chemrey	468.7	2,809	Snowbanks, glacier and springs	Southern aspect	*Tokpo* shared by Sakti and Chemrey

Each of the above watersheds is easy to reach and connected by motorable road with Leh. All of them are within a radius of about 60 km of Leh, the capital of Ladakh. They are all in the main Indus Valley; Alchi and Stok on the left and Phey and Chemrey – Sakti on the right of the river. Alchi and Stok are single villages located on glacial/alluvial fans. On the other hand, Phey and Chemrey-Sakti, particularly the latter, are fairly long valleys on the southern side of the Ladakhi range. In fact, a large number of villages and watersheds in the

district share similarities with these villages: location with a southern aspect, scarcity of water in early spring, little or no glaciers in the catchment area, fairly large irrigable area, and so on. Stok of course is a large watershed, but it is gifted with very large glacial masses; its only problem being its location to the north of the Zanskar range, which delays melting of glaciers/snow in early spring. Alchi suffers from a chronic shortage of water as there are no glaciers above. The limited snowbanks are not adequate enough to last the entire agricultural season. Consequently, shortage of water during the latter part of the season is the constraint as far as this village is concerned. Also, it is not a very typical watershed in that only one or two other watersheds (for example, Stakmachik) face similar problems. Phey was a bit too close to Leh; although being a small watershed a more intensive and in-depth study might have resulted. On the other hand, Chemrey-Sakti is a more representative watershed, and the report and recommendations based on it might have possibilities for replication in a majority of watersheds in the region. The present study thus includes the Sakti-Chemrey-Karu watershed with an emphasis on *pab-chu* which is perhaps unique to this watershed, though similar practices are prevalent in other large watersheds in the region.

3. THE WATERSHED

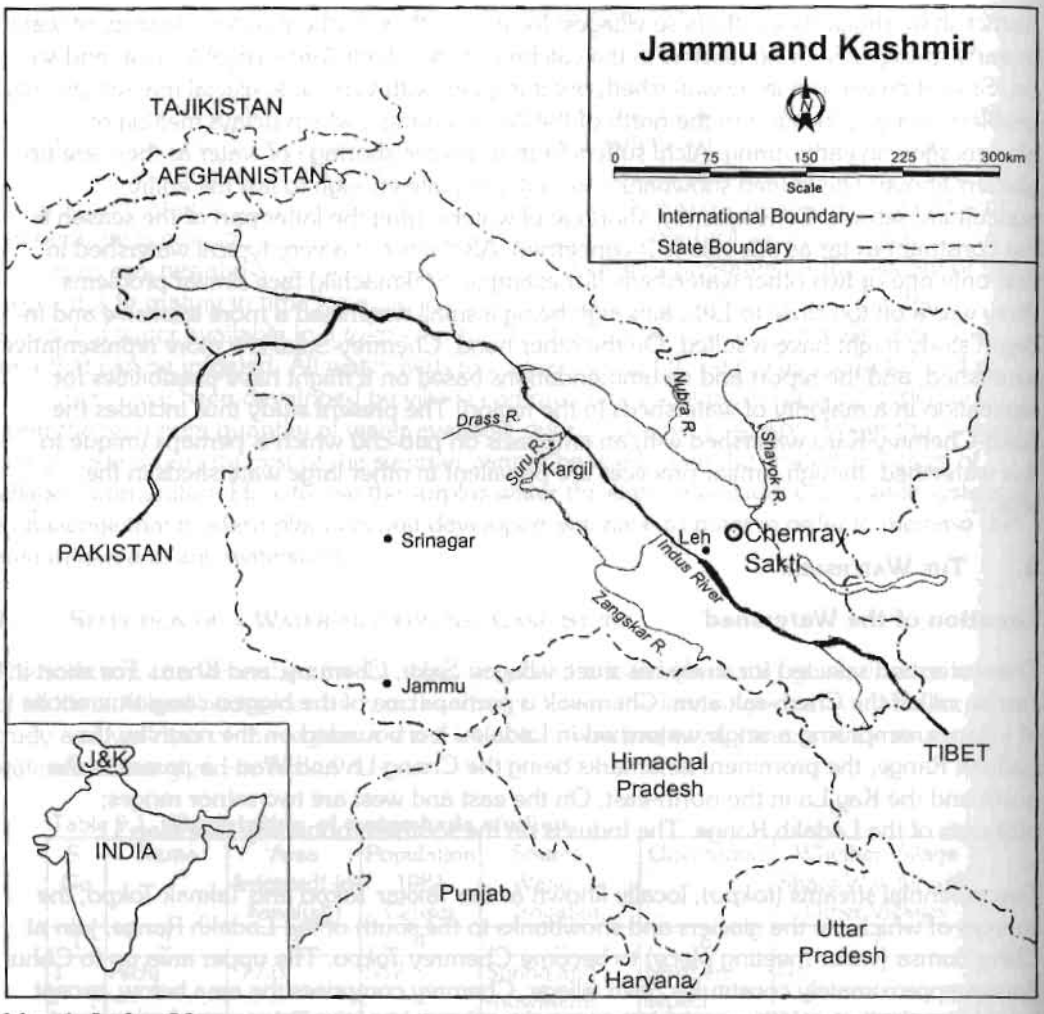
Location of the Watershed

The watershed selected for study has three villages: Sakti, Chemray, and Kharu. For short it can be called the Chem-sak area. Chem-sak is perhaps one of the biggest conglomerations of villages comprising a single watershed in Ladakh. It is bounded on the north by the Ladakh Range, the prominent landmarks being the Chang-La and Wari-La passes in the north and the Kay La in the north-east. On the east and west are two minor ranges; offshoots of the Ladakh Range. The Indus is on the southern boundary (see Map 1).

Two perennial streams (*tokpo*), locally known as the Takkar *Tokpo* and Taknak *Tokpo*, the sources of which are the glaciers and snowbanks to the south of the Ladakh Range, join at Chhu Zomsa (water meeting place) to become Chemrey *Tokpo*. The upper area up to Chhu Zomsa approximately constitutes Sakti village. Chemrey comprises the area below, except for the small village of Kharu which is situated on the right of the Tokpa in its lower reaches. Chemrey *Tokpo* joins the Indus at Kharu-do, which is located on the Leh-Manali/Leh-Nyoma road and is only 35 kilometres south east of Leh. Another important road going to Durbuk and Pangong takes off at Kharu-do and traverses the entire length of Kharu and Chemrey villages up to Dablung spring. The road then climbs in a rising gradient along the mountain on the left side of Takkar *Tokpo* in a series of hairpin bends until it crosses the Ladakh Range at Chang-La at an altitude of 5,358 m before descending to Durbuk and Pangong Lake area. One more road is under construction. This begins at Dablung spring and follows the left side of Taknak *Tokpo*. It will rise up to Wari-La (5,311m); its ultimate destination being Deskit in Nubra Valley. The watershed area is thus served well as far as roads are concerned.

Physical Attributes of the Watershed

The total area of the watershed 184 sq. km. Most of the area, however, is covered by dry and rugged mountain ranges, particularly to the east and the west, and contributes little to the watershed except for scattered bushes and other vegetable matter for fuel and grazing of animals. The mountainous area around Wari-La, Chang-La, and Key-La, on the other hand, is the source of water for the watershed, besides providing good summer grazing for animals.



Map 1: **Index Map**

The Y-shaped watershed has an eleven and a half kilometre trunk from Kharu-do to Chhu Zomsa and its upstream branches are each five and a half kilometres long up to the highest points where cultivation and permanent human settlements are feasible. Chang-La and Wari-La are again five to six kilometres away from these places as the crow flies.

Trade Centres of the Past

Earlier, Sakti and Chemrey were very important trading centres. During summer, Changpa, Tibetan nomadic traders, would come to Dablung with sheep, goats, and wool to barter for grain, and in the autumn they would come to Gamath in Chemrey to sell salt. At these times sheep and goats in thousands could be seen around the camp sites. The barter system involved considerable transactions in wool and salt as well as sheep and goats in exchange for *tsampa*, (ground barley) grain, apricots, and other products of Ladakh. The people of Sakti and Chemrey in general benefited from the trade. Some of the better-off families took an active part in the trade and made a profit. Unfortunately, after the 1962 India-China war, the trade stopped—to the economic detriment of the people of the villages.

Population

Of the three villages, Sakti is the largest in terms of population and Chemray the longest, the distance from Kharu-do to Dablung being eleven and a half kilometres. Kharu, situated on the right bank of the *Tokpo* in the lower portion of Chemrey, is the smallest. The populations of the three villages, according to the 1981 census were as follow: Sakti 1,620, Chemrey 1,060, and Kharu 129.Since no enumeration took place in 1991, the population in 1998 has been estimated at Sakti 2,600, Chemrey 1,700, and Kharu 200 (See Table 9.2).

Table 9.2: **Population of Chem-Sak Watershed**

Villages	1981	1991*	1998*
Sakti	1620	2120	2600
Chemrey	1060	1390	1700
Kharu	129	169	200
Total	2809	3679	4500

* Estimated

Religion

The villagers are almost all Buddhist by religion; there being only a couple of Muslim families in the entire watershed. Apart from the famous *Gonpa* (monastery) of Chemrey, the valley has the only Nyingmapa *Gonpa* (of Takthok) in Ladakh at Sakti, besides a small Gelugpa *gonpa* at Takar and the Kharu *gonpa* headed by the *Rimpoche* (reincarnate lama) of Stakna.

The three villages have a surprisingly large number of Lathos and La-Chang (Plate 1).

Geology

The valley of Chem–Sak is a longitudinal glaciated valley carved out of granite along the southern slope of the Ladakh granite complex. Three phases of granitic activity are reported: hornblende granite, hornblende biotite granite, and leuco granite with its appletic and pegmatitic veins showing an intrusive relationship with each other. The lenco granite is the most dominant and the youngest of all intrudes into the other varieties of granite present in the area. The hornblende granite is the oldest in this part of the Ladakh granite series. A few dolerite dykes also cross cut the granitic body in this area.

The granite, to the south, is uncomfortably overlain by a thick sequence of rhythmically bedded purple and green sandstone, shale, and conglomerates of the Indus Group. This contact is very well preserved South of Upshi on the left bank of the River Indus. The valley floor at higher level is covered by moraine composed of granite boulder at one to five metres with fine to coarse materials and gravel, cobbles, and stones. The glacial deposits descend steeply with the valley floor to merge with the alluvial terrace of Indus River. The alluvial terrace is standing five to ten metres above the present bank of the River Indus.

Soil

The watershed, as stated earlier, is a glaciated valley with the two sides comprising bare and rugged granite mountains between which are the glacial and culluvial deposits on which for over the ages have settled the villages of Sakti, Chemrey, and Kharu. The bed of the valley on either side slopes towards the *tokpo* which drains the valley. The soil comprising glacial and culluvial deposits is very similar to those obtaining in villages on the right of the Indus Valley in Ladakh. Generally, the soil in the watershed is considered to be very fertile and the villagers get a bumper harvest whenever there is no shortage of water in the *tokpo*.

Climate

Sakti is considered to be generally colder than Leh and it is at a higher altitude too. The altitude near Chhu Zomsa is 3,760 masl compared to 3,500 m at Leh. That Sakti is colder is indirectly corroborated by the fact that whereas wheat and fruit such as apples thrive in Leh, this does not apply to Sakti. Temperature data recorded by the Border Roads' Organisation (BRO) at Sakti and the Ladakh Ecological Development Group in Leh for one year seem to substantiate this, although in July 1998 Sakti was warmer by 1.36 degrees celsius during the day (Table 9.3). Table 9.3 also gives the temperature data for Changla where the minimum temperature is below freezing point throughout the year; the maximuim being above the freezing point only from June to October. This gives an indication of the time when snow or ice might possibly melt.

Table 9.3: **Irrigated and Irrigable Land**

Village	Area		
	Irrigated	Irrigable	Total Irrigable
Sakti	254.40	124.80	379.20
Chemrey	182.00	58.20	240.20
Kharu	32.30	13.50	45.80
Total	468.70	196.50	665.20

4. THE SOURCES OF WATER

The following passages discuss the main sources of water in the watershed.

Snowbanks

Although, like other villages in the district, not much snow occurs over the village, the depth of snow is greater in the higher reaches of the watershed. Unfortunately, no reliable data on snowfall in the higher reaches are available. Data for a year obtained from the Border Roads' Organisation (BRO) which maintains the road across Changla somehow appear to be far from reliable. The fact remains that the higher reaches receive considerable amounts of snow during the winter months which block the road sometimes for a week or two until cleared by deploying bulldozers as well as manual labour.

Rainfall

The average rainfall at Sakti may not be different from that of Leh, although the data made available by the BRO seem to show a much higher value. In the higher reaches more rainfall is received, particularly in the months of August and September—and this definitely should be contributing to the total water resources of the watershed at a time when the snowbanks have already melted away and water is required for the ripening of crops.

Glaciers

As the watershed is located to the south of the Ladakh Range, giving it a sunny aspect, only a few small glaciers are found in sub-valleys with northern aspects. Melting such glaciers should take place some time in late summer when there is solar insolation to melt the ice mass. In fact, there have been instances in which, during acute scarcity of water for irrigation, villagers have discussed the possibility of having a technology to induce glacial melt. The amount of water for irrigation contributed by rain, snow, and glaciers is unfortunately a question mark in the absence of reliable data.

Springs

There are quite a few springs, marshes, and oozing which visibly contribute their share, however small, towards the water resources in the watershed. Some of the larger springs and marshes are listed below.

1. Dablung (*spang chenmo*) spring and marshes (Plate 2)
2. Shagang Gnema *spang* marshes
3. Tsaskang Tubji spring and marshes

In the traditional Ladakhi water management system, springs and marshes have apparently received more than their due share of importance. In quite a few cases, certain families and hamlets situated immediately below springs or marshes have been deprived of any claim on the water from the *tokpo*. Four families: Kalaksa, Jonggar, Tongstot (1), and Tongstot (2) have an independent *Yura* (irrigation channel) by the name of Rumrum, which begins immediately below Dablung, to irrigate their fields. They have no right to the *tokpo*. Similarly, Shagangnema, with its springs and marshes, constitutes the source for irrigating the fields in Sabchak as well as the whole of Kharu village and the small hamlets up to Kharu-dho without any right, legal or traditional, to the water from the *tokpo*. Other examples elsewhere in the District are the hamlets of Skara below Leh and Ayu below Saboo which are exclusively dependent on springs and marshes without any right over the *tokpo* coming down from the upper parts of the village.

Agriculture

The areas irrigated, irrigable, and total irrigable land in the three villages as per the *riwaji-abpashi* (traditional irrigation system) of the Revenue Records are given in the box below. The irrigated area, it will be seen, represents only 2.5% and the total irrigable area only 3.6% of the watershed area. This is explained by the fact that most of the watershed area is covered by barren mountains. Even the 196.5 hectares of irrigable land which can be easily irrigated by the existing system, cannot be cultivated during certain periods of the limited agricultural season because of shortage of water. If water was not so scarce, there is enough land lying barren in Chemrey and Sakti which could be put to agricultural uses.

Only one crop can be grown in the watershed. Barley is the principal one; although some fields have peas or mustard. Only a very limited area in lower Chemrey is used to grow wheat. Similarly, fruit crops such as apricots and apples are rare and confined to Kharu and Kharudo.

5. WATER-HARVESTING TECHNOLOGIES

Yura and Zing

The *tokpo* that drain the watershed have their sources in the higher reaches of Changla and Warila in the Ladakh Range. The Takkar *tokpo* has two branches above Langday, one of them originating from a small glacier very close to Changla and the other from a glacier near Ke-la. Similarly, Taknak *tokpo* has three branches above Taknak. One of them begins at Wari-la and the other two, locally known as Zala Kongma and Yogma, have their sources in the small glaciers at the head of the *nallah* (valley) by the same name. The two *tokpo*, after joining near Chhuzomsa, continue downstream as Chemrey *tokpo* to join the Indus at Kharu-do.

The villagers of Sakti, Chemrey, and Kharu have, over the years, built numerous *yura* (channels or leats) draining out from the *tokpo* besides more than a dozen *zing* (tanks or ponds) for irrigation purposes. The *yura* are gravity channels dug in the soil and strengthened wherever required by drystone walls and rendered semi-impervious by using fine soil or sods. Each *yura*, at the place in which it begins, has a *raks* (crude bund or weir of dry boulders) thrown across the *tokpo* and a *rka* (sluice, generally a gap) with a *rka-do* (a boulder to close or

open) to regulate the supply of water at its mouth. The *yura* itself, some as long as a kilometre or even longer with velvety turfs and carpets of flowers on their banks, makes a pretty picture in the rural landscape of the village (Plates 3 and 4). Their utility and efficiency are living tributes to the ingenuity of the Ladakhi farmers. The *zing* (ponds) are dug into the native soil with earthen bunds towards the downstream side buttressed with rough drystone masonry (Plates 5 and 6). These also have crude but quite effective outlets for delivering the accumulated water for irrigation as and when the pond is full.

Sakti and Chemray are two fairly large revenue villages in the district of Ladakh. Sakti is traditionally supposed to have a 100 families and Chemray 80 families. The number of families has, of course, increased over the years, there being 314 houses in Sakti and 241 houses in Chemray according to the 1981 census. Both of them are divided into four *ngalakh* or *chutso mohallah* (neighbourhoods). The four *mohalla* of Sakti are called Takar, Taknak, Hamil, and Tukchu, and those of Chemray Gnala, Peu, Gamat, and Yoknes. For the purpose of revenue administration, each village is headed by a *Nambardar* with a *kotwal* (assistant to the village) in each *chutso* under him.

There are 18 *yura* (5 on the right and 13 on the left side) of Takar *Tokpo* and 17 (9 on the right side and 8 on the left side) of Taknak *Tokpo* making a total of 35 *yura* in Sakti. Each *yura* has a name and a list of the *yura* is given below.

Sakti Village

Takar*Tokpo*(*Yura* on the Right Side)

1. Tagar Dung *Yura*
2. Rekha *Yura*
3. Lungkay *Yura*
4. Ladong *Yura*
5. Khabrak *Yura*

***Yura* on the Left Side**

1. Langday *Yura*
2. Tagar Dung *Yura*
3. Piyang *Yura*
4. Rangi-shell *Yura*
5. Sumkha *Yura*
6. Toktseling Gongma *Yura*
7. Toktseling Yogma *Yura*
8. Khabrak *Yura*
9. Tongspon Khangyok *Yura*
10. Phaney Yurtung *Yura*
11. Tongspon Yurtung *Yura*
12. Kyangkar Gongma *Yura*
13. Kyangkar Yogma *Yura*

Taknak *Tokpo*(*Yura* on the Right Side)

1. Taknak Gongma *Yura*
2. Pharkey *Yura*
3. Khekhar *Yura*
4. Zarok *Yura*
5. Tunchu Gongyur
6. Tukchu Yogur
7. Pigmo Rig *Yura*
8. Korkor *Yura*
9. Tukchu Payur

***Yura* on the Left Side**

1. Yulgo *Yura*
2. Balti *Yura*
3. Lharjay *Yura*
4. Deygong *Yura*
5. Thabi *Yura*
6. Taktak *Yura*
7. Lalay *Yura*
8. Olthang Tingting *Yura*

Similarly, there are eight *yura* on the right and eight on the left side of Chemrey *Tokpo* up to Shagang Gnema. They are listed below.

Chemrey Village

Chemrey *Tokpo* (*Yura* on the Right Side)

1. Nalla Kongma *Yura*
2. Nalla Kongma *Yura*
3. Peu Gongma *Yura*
4. Peu Yogma *Yura*
5. Ziyuma Gongma *Yura*
6. Ziyuma Yogma *Yura*
7. Khalatse *Yura* Gongma
8. Khalatse *Yura* Yogma

***Yura* on the Left Side**

1. Yurlog *Yura*
2. Larak *Yura*
3. Ketong *Yura*
4. Koyur *Yura*
5. Payur *Yura*
6. Yogyur
7. Yognes *Yura* Gongma
8. Yognes *Yura* Yogma

Downstream of Shagong Gnema, there are nearly a dozen *yura* in Sabchak, Tangye, Kharu, Tharmat, and Kharudoo. These have not been listed as they are entirely dependent on the springs and marshes of Shagang Gnema and have no right over the water of the *tokpo*.

In addition to the *yura* there are as many as 14 *zing* (tanks) in Sakti and Chemrey above Shagang Gnema. There are nine in Sakti and five in Chemrey:they are listed below.

Sakti

1. Sumkha (Sherney Takar)
2. Nagluk,(Sherney Takar)
3. Kyangkar (Takar)
4. Kyangkar Yogma (Takar)
5. Kalaksa (Hamil, Taknak)
6. Kharchug (Hamil, Taknak)
7. Tukchu Gongma (Tukchu, Taknak)
8. Pingmoring (Pharka, Taknak)
8. Tukchu Yogma (Tunchu, Taknak)

Chemrey

1. Gnala Gongma (Gnala)
2. Gnala Yokma (Gnala)
3. Peu (Ppeu)
4. Zeoma (Gamat)
5. Zing Chhenmo (Yoknnes)

Other Technologies

The *yura* and *zing* described above are the main water-harvesting technologies prevalent in the watershed. In fact these are the structures mostly in use in all the watersheds of the district. In addition there are some technologies peculiar to the watershed, or which are not very common. These are described in the ensuing passages.

Yursal or Yursar

There are two *yura*, one on Kay *Tokpo* above Tagar and another on Wari *tokpo* above Taknak, which divert the water from the parent *tokpo* for a kilometre or more but do not directly irrigate any fields. Both of them are at around 4,500 masl. They are given the name *yursar* (new *yura)* or *yursal* (cleaning the *yura*). The nomenclatures do not explain the purpose of the *yura*. According to the villagers, a considerable portion of the discharge of

the parent *tokpo* somehow disappears if the water is allowed to continue flowing in it. Perhaps the water infiltrates into loose glacial deposits and subterranean channels and ultimately into underground aquifers, most probably to reappear as springs and marshes, but is lost to the farmers for immediate irrigation of their fields. The *yursar* which are built as gravity channels along the mountain slope avoid the portion of the *tokpo* where water visibly disappears. The water thus saved rejoins the *tokpo* at a lower point and becomes available for immediate use. During the old days, these used to be repaired and maintained by the villagers of Tagar and Taknak. For this, the villagers downstream, it is said, would contribute some grain for *yursal*, i.e., cleaning the *yura*. This apparently gave the name *yursal* to these *yura*.

Snow Fencing

In the old days the villagers constructed stone walls at right angles to the generally prevalent wind direction in Chang-la and Wari-la with a view to encouraging the deposition of snow on the leeward side of the wall. Remains of such walls can be seen even now. About two decades ago, the Public Works Department (PWD) built such walls a little below Wari-la. According to the villagers, these were very effective. Unfortunately there has been no proper monitoring and follow-up action. Snow fencing encourages deposition of snow thereby leading to moisture conservation and is mentioned in the Agricultural Yearbook of the U. S. Department of Agriculture (1995).

Ice Formation for Moisture Conservation

Two years ago boulders were placed as bunds across the *nallah* above Tagar. The idea behind this venture was that the water, when obstructed by the bund, would freeze and accumulate behind it and, on melting in early spring, would augment water resources. Unfortunately, the water did not freeze, although similar experiments in the *tokpo* at Shara are said to have been a success.

6. MANAGEMENT AND DISTRIBUTION OF WATER FOR IRRIGATION

Given the extent of the watershed area spread over a length of 16 to 17 kilometres, and the rather large irrigated area in the watershed of 665 hectares, management of irrigation in the watershed is bound to be problematic. This is accentuated by the fact that the watershed is comprised of three independent villages: Sakti, Chemrey, and Kharu. Sakti, located in the upper reaches of the watershed, obviously enjoyed a natural advantage, besides being the bigger in terms of population as well as cultivated and cultivable areas. Chemrey, though located downstream from Sakti with a smaller population and lesser-cultivated area, had its own sphere of influence historically insofar as it was the seat of one of the large monasteries of the Khagyudpa sect. Kharu is the smallest village and apparently had no claims whatsoever on the water of the *tokpo*. It depends on the springs and oozings of Shagang Nyema (marsh/meadow), which it shares with the Sapchak settlement of Chemrey, and Tsaskang Tupji spring, besides whatever surplus water is available in the *tokpo* after meeting the requirements of the irrigated areas in Sakti and Chemrey above Shagang Nyegma.

The villagers of Chemrey and Sakti, it appears, were always in an adversarial situation as they were dependent on the same *tokpo* for irrigation. For equitable distribution of the limited water, villagers had evolved a system by which water for certain days and nights was diverted to Chemrey by closing the mouth of all the *yura* (irrigation channels or leats) in Sakti. This was known as *pabchu* (water brought down by closing the *yura* upstream).

History of *Pabchu*

The earliest historical reference to the *Pabchu* system is found in an order issued by King Jamyang Namgyal in 1571 A. D. which stipulates that the water flowing in the two streams from the upper valley would be used for eight days and nights by Sakti village and four days and nights by Chemrey village.

Inevitably, as happens in such cases, there were disputes between the two villages and the matter reached the court of King Deldan Namgyal who issued an edict on the 16th day of the third month of the year of the snake, corresponding to the year 1629 A. D. , from the palace at Sakti. The order, while making mention of the repeated disputes over water for irrigation between the two villages and their inability to give a clear picture due to their respective village interests, had increased the number of days/nights by two in favour of Chemrey to 14 days/nights. Strangely enough, the order is silent as to when Sakti will irrigate its fields. It also requires the people of Chemrey to offer the meat of one sheep or goat and 12 pots of *chhang* (a local brew made from barley) to the people of Sakti. The custom of offering meat and *chhang* by the villagers of Chemrey continues to this day and is known as *Sha-Chhang* (meat-*chhang*). Tsespal Namgyal, who was the last king of Ladakh, before, the region was incorporated into the Jammu kingdom in the 1830s, as a result of the conquest by General Zorawar Singh of Maharaja Gulab Singh of Jammu, also issued an edict. The original copy of this order is available in Chemrey *Gonpa*. While mentioning the earlier orders of Jamyang Namgyal, Deldan Namgyal, and Tsewang Namgyal and their violation by the people of Sakti, the order again stipulates that Sakti people would use the water for eight days/nights and Chemrey for four days/nights. It further requires the Chemrey people to deliver *Sha-Chhang* to the Sakti people on the first of the third Ladakhi month and from that day until harvest the people of Chemrey are entitled to four days/ nights and the people of Sakti to eight days/nights.

The *riwaji-abpashi* for Chemrey, which was prepared during the first decade of the 20th century, is silent about the *pabchu*. However, and rather fortunately, the *riwaji-abpashi* for Sakti village makes specific mention of the entitlement to water for irrigation in favour of Chemrey village. An English translation of the relevant extract from the *riwaji-abshi is* reproduced below.

"In case there is an acute shortage of water, over a five-day period, water from the two streams for a day and night is taken by the people of Chemrey and water for four days and nights used by Sakti. Ngerpa of Chemrey *Gonpa* accompanied by the villagers of Chemrey divert the water from Taggar and Tagnak by fixing seals for one day and night. "

As prevalent today, the villagers of Chemrey draw the water of the *tokpo* for two nights and the intervening day, Sakti villagers using the water for seven days and six nights. The entitlement to water of the two villages as per the various royal orders, *riwaji-abpashi*, and the situation on the ground as of today, which has the obvious acceptance of both villages, is given in Table 9.5.

The Pabchu

The royal orders and a *Riwaj-i-abpashi* specify the periods for which the water of the *tokpo* will be shared between the villagers of Sakti and Chemrey. It is now proposed to describe in detail how this operates on the ground at present. The entire operation is known as *pabchu*. In the *pabchu* system the villagers of Chemrey upstream of Shagongnema use the water for

Table 9.5: **Entitlement to water for irrigation in Sakti and Chemrey according to royal edicts and other documents**

S. No.	Reference to Royal Order/ Other documents	Entitlement	
		Sakti	Chemrey
1.	King Jamyang Namgyal 1571 AD	8 days/nights (66.6%)	4 days/nights (33.3%)
2.	King Deldan Namgyal 1629 AD	Order silent	14 days/nights
3.	King Tsespal Namgyal	8 days/nights (66.6%)	4 days/nights (33.3%)
4.	*Riwaji-Abpashi*	8 days/nights (80%)	2 days/nights (20%)
5.	Present Situation	6 nights + 7 days (81%)	2 nights + 1 day (19%)

two nights and the intervening day and the villagers of Sakti for seven days and six nights thereafter. The lower portion of Chemrey comprising of 15 families of Yognes and 26 families of Gamat are responsible for the management of *pabchu*. Chemrey *gonpa* with most of its fields (nearly 18% of all fields) in these two *mohalla* has an important role. The villagers of Ngalla and Peu, although part of Chemrey, do not have any role in the management of the *pabchu*.

The first event in the *pabchu* system in the irrigation season is the delivery of Sha-Chhang (meat and *chhang*) comprising of a sheep or a goat and 16 pots of *chhang* (barley beer) by the representatives of Chemrey village to the villagers of Sakti. Of Late, IRs 500/- is paid in lieu of the meat. This takes place on the 3rd day of the 3rd month of the Ladakhi calendar. The meat and *chhang* are contributed by the *gonpa*. The actual *pabchu* can start on the 8th day of the 5th month of the Ladakhi calendar. Every time Chemrey requires a *pabchu*, a pot of *chhang* is delivered one day earlier to the headman of Sakti village. Sometimes Chemrey village may require an extra *pabchu* or two. This generally happens when the Ladakhi year has an extra month. In such cases people from Chemrey make a *shabe* (special request) for an extra *pabchu* for which again a pot of *chhang* called *shadam* (literally a water bottle) is delivered to the headman of Sakti. On the day fixed for a *pabchu*, one member each of all the 41 families of Gamat and Yognes proceed to the various *yura* to divert the water. The team is led by two *Churpon*(s) (village water overseers), one each from Gamat and Yognes, two *Chukorpa*(s) (water supervisors) supervise the operations and two *Thetse-pa*(s) whose duty is to affix an impression of a *the-tse* (wooden seal) (Plate 16) on a bund across the mouth of all the *yura* above Zeomazing. Each family is allotted a *yura* or two for watch and ward, and the turn is fixed for three years by drawing lots. The *Churpon*(s) were earlier elected by the villagers when persons with qualities of leadership and influence were preferred. Generally this took place after the conclusion of *saka* (ceremony to work at the date for the first ploughing of the season). Of late the status of the *churpon* seems to have dimished and the position is being assumed on a turn by turn basis. The same thing has happened with the *Chukorpa*(s). Earlier the position was held by two prominent families, the Nyerpapa and Tongspon, in the the village.

In the past, the *Gonpa* also took a very active part and contributed a team of six persons: the *Ngotsab* (representative of the Chhagzot), *Nyeryog*, two senior lamas, and two junior lamas. No one from the *Gonpa* participates now. If found absolutely necessary the *Chhagzot* (manager) sometimes puts in an appearance. The representatives of the 41 families of Gamat and Yognes, including the two *Churpon*, two *Chukorpa*, and the two *thetse-pa* leave for Sakti late in the afternoon when the lamas of Chemrey Gonpa are called to *Tsok* (assembly) by ringing the *Gyalna* (royal gong) from the roof of the *Gonpa*. This is at

about 3 p.m. The two *thetse-pa(s)*, after diverting the water, fix the wooden seal on each of the *yura* up to the *chuzomsa* and then one of them proceeds to Tagar and the other to Taknak, repeating the operation on each *yura*. Meanwhile, the representatives responsible for the watch and ward of the *yura* station themselves at the headworks of the *yura*. The five *yura* between Zeoma *zing* and *Zing* chhenmo are closed simultaneously and representatives from Yognes are responsible for their watch and ward, although no seals are impressed on these. The water now flowing down the *tokpo* for the whole night is stored in Zeoma *zing* and *Zing* chhenmo by roughly dividing it into two equal parts. This goes on for the following day and the next night also, except that three *yura*, namely, Tagar Dong, Rangi Shell, and Khabrak in Sakti are entitled to *Do-tam* from mid-morning (about 10 a.m.) until shadows appear on Urgain Tak (a rocky feature opposite Taktak *Gonpa*) in the evening (about 5 p.m.). *Do-Tam* means a mark on a stone, a sort of gauge to determine the depth of water to be let into the *yura* which is apparently a concession from villagers of Chemrey to the fields belonging to the *Gonpa* and the Kalon family. Lalay *yura* on Taknak *tokpo* also gets *Do-Tam*. According to the Chemrey villagers this was extracted by the head of an influential family on the plea that fish will perish if the *yura* is completely dry. In fact, sometime the *Do-Tam* for Lalay *yura* is called *nyachu* (water for fish). The six *yura* in Ngala and Peu *mohalla* in Chemrey, namely, Ngala Gongyur, Ngala Yogyur, Peu Koyar, Peu Yokyur, Yarlok, and Larak are also entitled to *Do-Tam*. Earlier representatives from Ngala and Peu went to Khabrak on the Tagar *tokpo*, where the *Ngotsab* of the *Gonpa* would be camping, to request the *Do-Tam*. Now that the *Ngotsab* does not participate, the *Do-Tam* for the six *yura* are allowed automatically, the timing being the same as for the *yura* in Tagar *tokpo*. Kiting and Zeema Kongma *yura* are allowed water from early morning besides the *Do-tam* as families under the two *yura* take part in *pabchu* operations also.

At about 5 p.m. in the evening when shadows appears on the Urgain Tak, *Do-tam* is discontinued and the *yura* are again sealed by the *thetse-pa*. Water from all the *yura* continues to flow down to Zeoma and Zing chhenmo during the night. During the late hours of the second night, when the sparrows begin to chirp (about 4 a.m.), the villagers of Gamat and Yognes, who have been guarding the *yura* for the previous two nights and the intervening day leave for their homes, thus signalling the end of a *pabchu*. The farmers of Sakti and Ngala and Peu in Chemrey then divert the water of the *tokpo* into their *yura* as per arrangements applicable during the non-*pabchu* period.

Distribution of Water from the *Pabchu* in Gamat and Yoknes

The water that flows down on the first night is called *pabchu* and that of the second night *chatchu* (water to be cut off). The flow is naturally greater during *chatchu*. During an extremely dry season, *pabchu* water which reaches Zeoma *zing* at about midnight and *Zing* chhenmo a little later can hardly fill the two *zing* by morning. When full, the *zing* can irrigate about half its command area. Once Zeoma *zing* is filled, Gamat can use its share of the water by diverting it into its *yura*. Since the two *zing* and *yura* under them happen to be the main beneficiaries of *pabchu*, details about the two *zing* and *yura* under them are given in Table 9.5. It will be seen that the capacity of Zeoma *zing* is 2,550 cubic metres and that of *Zing* chhenmo 2,830 cubic metres. The two *zing* together irrigate about 118 hectares of which 8.73 hectares are *Majing* (best land) 85.08 hectares *Barjing* (average land) 8.95 hectares *Thajing* (poor land), 5.05 hectares *Olthang* (pastures with alfafa or lucerne crops), and 10.09 hectares others (miscellaneous).

The water collected in Zeoma *zing* or *Zing* chenmo is distributed through the *yura* by dividing it into four equal parts to four groups of families in each *zing*. Each group is headed

by a *margo* (group leader) and the water is rationed in order to irrigate the maximum area in each group.

Distribution of Water during the non-*Pabchu* Period in Different Villages

Chemrey-Chemrey village comprising four *mohalla* has its own management system for distribution of water from the *tokpo* during the non-*pabchu* period. While water during the day is used by the villagers of Ngala and Peu, all the *yura* of Ngala and Peu are closed and water diverted to Gamat for two nights and to Yognes for one night. This arrangement is called *ziray*. The *yura* below Zeoma *Zing* in Gamat are also closed on the night when Yognes gets the *ziray*. During a *ziray*, half the villagers of Gamat are involved in diverting the water of the *yura* in Ngala and Peu which is stored in Zeoma *zing* and subsequently used for irrigation of the fields. During the next night, the other half of the village does the same. The same arrangements are made for the night when Yognes gets the *ziray* except that they have to arrange for watch and ward of the *yura* between Zeoma and *Zing* chhenmo also. The water of course is stored in *Zing* chhenmo and used during the day for irrigation.

The villagers in Yognes are entitled to the water of the *yura* below Zeoma *zing* during the night when Gamat receives *ziray*. This is called *zaga*. For *zaga* the families in Yognes are divided into four groups and a group manages the diversion of water from the *yura* below Zeoma and it is used for irrigation after storing it in *Zing* chhenmo. It will thus be clear that during the six non-*pabchu* nights Gamat gets four *ziray* and Yognes gets two *ziray* and four *zaga*. For ziray and *zaga*, a day is reckoned from chirping of sparrows in the morning to the ringing of GyalGna from the roof of Chemrey *Gonpa* (about 3 p. m.).

Sakti-Being located upstream, Sakti has little problem in the distribution of water during the non-*pabchu* period. Generally, the upper portion of the village irrigates during the day and the lower portion during the night by storing in *zing*. Takar proper uses the water of the *tokpo* from the rising of *minduk* (the Pleiades constellation which appears at about four a. m.) in the morning sky to mid-morning (about 10.00 a. m.) followed by Kyankar up to mid-day. From mid-day to evening, it is again the turn of Takkar proper. Sharney collects the water from evening to the rising of *minduk* by storing it in the two *zing* of Sumkha and Nakluk and the fields are irrigated the next morning.

Table 9.6: **Salient features of the irrigation system in Gamat and Yognes *Mohalla*(s)**

Zing		Yura			
Name of *zing*.	Capacity in cm	Name of Yura	Approx. capacity (cumecs)	Approx. length metres	Area irrigated (ha)
Zeuma *Zing* (Gamat)	2550	(a) Zeoma Yogma	0.05	520	3.95
		(b) Koyur	0.15	1560	17.51
		Payur	0.17	1000	11.64
		Yogyur	0.14	600	31.82
Zing Chhenmo (Yognes)	2830	Yura Kongma	0.16	750	27.60
		(c) *Yura* Yogma	0.17	1500	20.11
		Khalatse *Yura*	0.05	250	5.25
				Total	117.88

On the Taknak side, night water is used by Hamil and Tookchu by storing in Kalaksa, Kharchung, and Tukchu Kongma *zing*. The higher portion of the village —Taknak proper— uses the water during the day. Some of the lower *yura* are free to use whatever water is flowing in the *tokpo* both day and night.

Distribution of Water in Sabchak and Kharu

As stated earlier, areas below Shagang Gnema, comprised of the Sabchak and Kharu-Do hamlets of Chemrey and Kharu villages, have no claims on the *tokpo* water. They are completely dependent on the spring and oozings of Shagang gnema and other springs. Whereas Sabchak gets the water during the day, the water for the night is shared by Sabchak and Kharu Kongyur on alternative nights. The other *yura* depend on the springs downstream of Shagang gnema and whatever water may be flowing in the *tokpo*. It appears that Sabchak and Kharu generally do not face a shortage of water for irrigation.

7. OTHER RELEVANT ISSUES

Other Uses of Water

With farming as the main economic activity, irrigation is naturally the most important use of water in the watershed. For human consumption, people generally depend on the *tokpo*, although Sakti has a rudimentary piped water supply based on springs as the source which works during the summer months but has to be stopped in winter because of freezing conditions. The rising population and Army and Border Roads' Organisation (BRO) camps in the watershed are possible sources of contamination. A gravity scheme for Chemrey that began about 20 years ago has failed to function. Recently, a tubewell was drilled and hopefully the village will have a piped water supply in the near future.

As for the domestic animals, the *tokpo* will continue as the source for drinking water in the future also. There are no other demands for water from other sources except for irrigation to meet the demand for extension and intensification of agriculture from an increasing population.

Gender

Gender was a non-issue in traditional Ladakhi society in which women enjoyed a status in no way inferior to that of men. Women as mothers enjoyed special privileges in the family. Their role in agricultural activities was to prepare food and carry it to the work site, perhaps assisted by a grown-up daughter, while the men, including neighbours with whom the family has *bes* arrangements, were engaged in various laborious activities required from time to time. In fact most of the tiresome activities are carried out by men; lighter work such as sowing, levelling fields are carried out by the young, women, and the elderly. The special status of women in the traditional society is perhaps reflected by the fact that the best field of the family is given the name *majing* (mother's field) and to married daughters the parental home is the *makhang* (mother's house). Recent developments resulting in the men seeking paid employment, however, have put women under greater pressure and they have to spend more time engaged in agricultural activities which were traditionally done by the men.

The Traditional Water-harvesting Technologies

The traditional water-harvesting technologies have made a significant contribution to the development of the agricultural system and society in the region. These, particularly the

ones based on *tokpo* and springs, make optimum use of water resources within the constraints of the seasonal water supplies and the short summer season when crops can be grown. Earlier, there was also the over-riding importance farmers gave to the production of cereals to meet their food requirements. The possibility of using the surplus water during the summer months for growing short duration crops like mustard, fodder, and vegetables on new areas to meet the growing demands of an increasing population needs to be examined. There is also scope for improving the efficiency of existing irrigation systems by reducing the transmission and seepage losses in the *yura* and *zing*. This will require identification of locally-available materials that are less susceptible to damage from frost for lining the *yura*.

The experiments already carried out for moisture conservation as ice and snow should be pursued and results thereof, if found viable economically, used to evolve suitable guidelines for identification of sites and specifications such as type, size, and spacing of structures required.

New technologies such as drip and sprinkler irrigation systems may be tried to establish their suitability for the local environment and crops.

Management System

The traditional management systems that have evolved over time in a traditional society obviously cannot meet the present day requirements when there are competing and conflicting demands for labour and other resources. This is clearly brought out in the case of *pabchu* in which forty or more people from Gamat and Yognes in Chemrey have to spend 36 hours guarding 50 or more *yura* during each round of *pabchu*. At an average daily wage of Rs 125 for labour, the total expenses for one *pabchu* in terms of wages alone will be around IRs 10,000. If an agricultural season requires five *pabchu*, this would mean IRs 50,000 per year. On the other hand, it should not be difficult to work out an equally, if not more, efficient system requiring at most 10 people to ensure the operation of the *pabchu*. This will need many meetings and discussions among the villagers of Chemrey leading to the constitution of a committee under a *Churpon* with initiative and qualities of leadership for management of the *pabchu*. It will also require negotiation and consultation with the villagers of Sakti and Ngala and Peu of Chemrey. The committee at a later date, when the Panchayati system is introduced, may function as a sub-committee of the *Panchayat*.

At present *yura* and *zing* are being repaired with funds provided by the Block Development Officer (BDO). Traditionally, these were carried out by the villagers voluntarily and regularly. They have now become dependant on government funding and when the funds are not forthcoming the *yura* and *zing* remain unrepaired. The proposed committee should be made responsible for the annual maintenance of the water-harvesting structures for which the necessary funds can be made available by the BDO through the *Panchayat* on a yearly basis.

Role of Non-government Organisations(NGOs)

Non-government Organisations have not done any work on water harvesting or management in the study area so far. The Government of India has introduced the concept of watershed development under the Desert Development Agency (DDA) and Sakti, Chemrey, and Karu will be taking up the programme soon. The programme, which is based on a participatory approach at the grass roots' level, will be funded by the DDA, each watershed getting an IRs 2,500,000 spread over a period of four years. Chemrey, Sakti, and

Kharu, considering the area and population, have been designated as four watersheds. Each watershed will have a general body representing all the families in the watershed with a Watershed Association to plan and implement the programmes. The necessary technical expertise will be provided by the Watershed Development Team (WTD) of the Project Implementation Agency (PIA), which ideally should be a Non-government Organisation, but can be a government department also in which no NGO is involved. In the case of Chemrey, Sakti, and Karu, the Leh Nutrition Project (LNP), a well-known local NGO, is the PIA which will coordinate the programmes in 10 to 12 watersheds through its WTD of four experts, one each in the fields of Social Sciences, Engineering, Agriculture, and Animal Husbandry.

Role of Government Agencies

Little has been done in the sphere of water harvesting and management by government agencies as far as the area under study is concerned. The Rural Engineering Wing (REW) of the BDO has been spending some money every year, mainly on repairing existing *yura* and de-silting of *zing*. The only interesting work carried out so far by the department is the construction of some bunds across the *tokpo* above Taknak with the idea of encouraging formation of ice behind the walls which, on melting, would perhaps increase the water resources in the watershed. Unfortunately, freezing water somehow failed to materialise in Taknak, although similar experiments are reported to have proved successful elsewhere.

The REW has used some interesting and innovative technologies based on traditional knowledge at other places in the district. A couple of *yura* have been successfully built through very loose strata, rendering the section of the *yura* semi-impervious and thereby capable of holding water, by encouraging the growth of mustard or millet—the seeds of which are floated into the downflow of water. This is an interesting phenomenon much talked about by the locals in the past and REW has demonstrated its efficacy by actually employing it in a couple of *yura* it has built.

The PWD had been investigating the possibility of diverting some water flowing towards the north of Warila to Sakti. So far nothing concrete has emerged regarding the feasibility of such a venture.

Difficulties Encountered in Carrying Out the Case Study

Lack of basic and up-to-date data about the region as well as the study area was perhaps the most critical issue. The study took place late in the agricultural season and as a result it was not possible to ascertain the availability of and requirements for water for irrigation from time to time. In future, such studies should ideally cover at least one complete agricultural season, thereby enabling collection of more data covering all facets of the activities involved.

8. RECOMMENDATIONS

1. The traditional system of water management needs to be revived and, in cases like that of the *pabchu* system, streamlined, resulting in the involvement of less labour and expenditure. Steps are needed to ensure proper capacity building at the village/*mohalla* level through a participatory approach ultimately leading to the formation of small committees for management of the systems.

2. The existing water-harvesting technologies, such as *yura* and *zing*, require improvements with a view to minimising transmission and seepage losses. To start with, the idle length of the *yura* should be improved by providing a lining. Suitable local materials less susceptible to damage from frost and involving minimum use of materials like cement will have to be identified.
3. Use of polyethylene film could also be tried for lining *zing*.
4. Studies and experiments on moisture conservation in the form of ice and snow should be continued and systematically monitored. The results of these experiments used to prepare guidelines for adoption at suitable sites.
5. New technologies such as drip and sprinkler irrigation systems should be tried out in some small watersheds to establish their suitability for the environment of Ladakh and for the types of crop grown.
6. More case studies on water-harvesting technologies and management systems should be tried out over a full irrigation season and they should include discharge observations at various sources, studies in consumptive use of water for different crops, and estimates of evaporation losses so that more comprehensive recommendations covering the various technologies and irrigation practices can be formulated.

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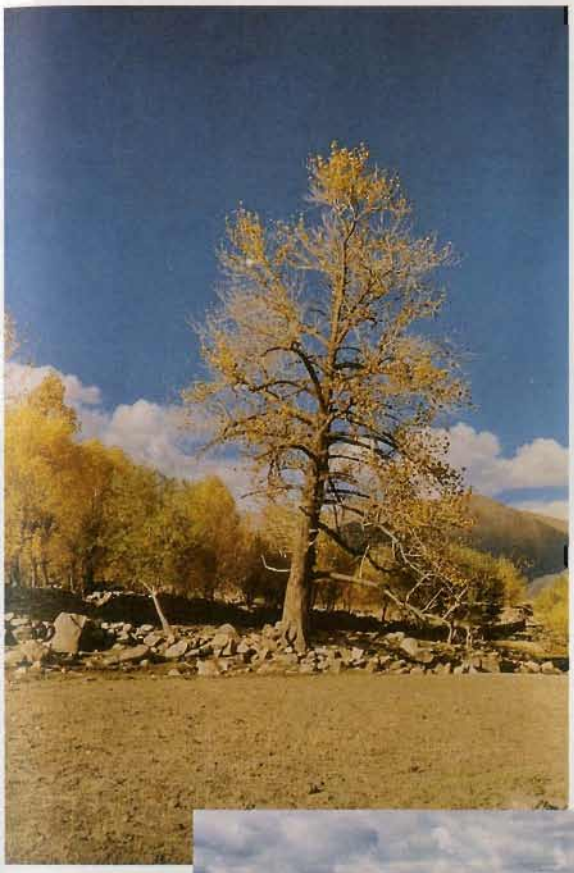

Plate 1: **View of a La-chang**

Plate 2: **Chemrey as seen from a vantage point at Sakti. Dablung springs in the foreground and Zangskar range in the background**

Plate 3: **View of Kitong *yura***

Plate 4: **View of a *yura***

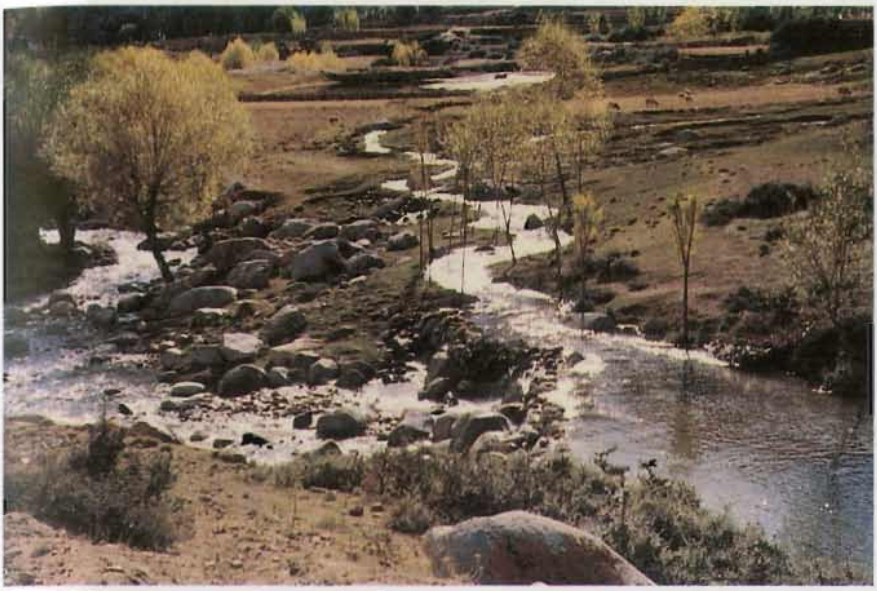

Plate 5: **Zioma zing with *yura* feeding it**

Plate 6: **Zioma *zing* from downstream site**

Plate 7: **Zing chenmo**

Plate 8: **Zing chenmo viewed from downstream**

Plate 9: **The-tse, the wooden seal**