Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2021, Volume 34, Issue 1, Page 1-15

Traditional rice landraces and Indigenous knowledge associated with the rice cultivation in Sikkim Himalaya: An analysis based on local farming practices.

Deepak Chettri[1] & N. Sathyanarayana[1*]

[1]Molecular Biology and Biotechnology Laboratory, Department of Botany, Sikkim University, 6th Mile, Gangtok, Sikkim,

ARTICLE INFO

Article history:
Received : 5 August, 2020
Revision: 10 September, 2020
Accepted 5 October 2020

Key words: Cultivation practices, Rice landraces, Sikkim-Himalayas, Traditional knowledge, Agriculture.

ABSTRACT

This paper reports collection of rice landraces and documentation of traditional knowledge associated with rice cultivation in Sikkim Himalayan region. The methodology employed was- field visits accompanied with survey using purposive-cum-random sampling method, particularly of the elderly farmers. A total of thirty seven farmers from twelve selected villages of the four districts of Sikkim state were interviewed randomly as respondents. As many as seventy four different rice landraces were collected as part of this research. The maximum number of Indigenous Traditional Knowledges ITK was documented under the plant protection against various diseases (10 nos.) and only two ITK was recorded in water management. The rationale on the use of indigenous knowledge, presented here, is derived purely based on the free opinion of the respondents. The results suggest that the indigenous knowledge in rice farming in Sikkim Himalayas is built upon the natural features of the region. The innovation/techniques are based on locally available resources and are rooted in their historical experiences which are passed on through generations. The information on ITK presented here could provide vital clues on the suitable alternatives to expensive modern farming system.

1. Introduction

Sikkim has a glorious history of agriculture that has been practiced from generations where people and nature lived in perfect harmony. As is the case elsewhere, the system graduated from hunting and gathering to shifting cultivation to settled agriculture (Subba, 2009). In Sikkim, the cropping pattern over the years has been transferred from cereal dominated subsistence agriculture to high value, cash crop dominated commercial agriculture. Since the state is a completely hilly area, the agriculture is mostly rain-fed and rice is transplanted (Singh, 2011). The system of farming here was time tested, deeply interwoven with ecological system and climatic conditions, and founded on sustainable agricultural practices. However, with the emergence of modern agricultural methods, the indigenous farming practices used for centuries have been sidelined. Traditional varieties have been replaced with high yielding ones. These crops and varieties have attracted new pests and diseases. Soil health is on deterioration and, microorganisms have declined. With an idea of transforming Sikkim into an organic state, the Government of Sikkim made a historic declaration to transform Sikkim into a totally organic State in the year 2013. The decision of the Government of Sikkim to go organic was based on the fact that farming in this hilly state was traditionally organic.

Rice is the most important staple cereal crop of Sikkim grown at an elevation ranging from foothills to 1700 meters above sea level (m asl). Paddy constitutes the second-largest area of about 15 percent (10,327 ha) of the total cultivated area of the state. Its average annual production is around 10,271 tonnes. The average yield per hectare is 694 kg, which is low compared to all India average of 1073 kg (Portel, 2015). The principal rice-growing districts in the order of importance are East (33.07%), West (14.31%), South (10.13%) and North (4.42%) (State Profile of Sikkim, 2011). The share of rice as the main food item in the total food production has been

*Corresponding author: nsathyanarayana@cus.ac.in

hardly 20 percent. The per capita availability of rice in the state is 158 gm/day which is far below the national average of 417 gm during 2001-02 (Economic Survey of Sikkim, 2006-07). This shows that the state is deficit in rice production. The low availability of paddy as a major crop in the state is attributed to the shrinking of the land under paddy cultivation due to several developmental activities (Economic Survey of Sikkim, 2013) and relative increase in the substitution of cash crops farm for food crops. Out of total area under paddy cultivation in Sikkim 12.14 Tha (Thousand hectares), 40.7 percent i.e. 4.95 Tha belongs to East district followed by West 32.7 percent. The area under paddy field in East District covers 23 percent of the total paddy field in the state. Since Sikkim has a wide variety of paddy, almost all wet arable areas of Sikkim are devoted to paddy cultivation (FS&ADD and H&CCDD, GOS, 2010).

Indigenous knowledge is the knowledge of indigenous people inhabiting the diverse geographical area of the world with their own language, culture, tradition, belief, folklore, rites and rituals (Chhetry and Belbahri, 2009). Rice farming, although non-remunerative, is a major livelihood activity of the region. The age-old enterprise has provided a pearl of unique wisdom to farmers. Right from sowing to harvesting and preservation/storage, traditional practices in the region stand on a sound footing. These indigenous technologies have been developed as per need, capacity and local ecology. Hence the present study was undertaken to understand and document the traditional rice landraces and indigenous knowledge associated with the rice cultivation practice in Sikkim Himalayas which has now become immensely important in view of the speedy extinction of many native landraces with good quality attributes from the agricultural system. It is hoped that the findings of this study would help to evolve the strategy for rice cultivation and the results of the study would also provide new vision to the agricultural scientists to refine the ITK in the region to increase its utility and adaptability.

2. Methodology

2.1 Study area

The study area was all the four districts of the state of Sikkim. It came into existence as 22nd state of Indian republic on 16th May 1975 and has a land area of approximately 115 km from north to south and 65 km from east to west surrounded by vast stretches of Tibetan Plateau in the north, Chumbi Valley of Tibet and the kingdom of Bhutan in the east, Darjeeling district of West Bengal in the south and Nepal in the west. The state is located at the foothills of Eastern Himalayas between the latitude of 27°49" and 28° 10" north and the longitudes of 88° 28" and 88^{0} 55" east. The state is a part of inner ranges of the mountains of Himalayas without open valleys and plains. It has carried elevations ranging from 310 (Jorethang) to 8583 m asl consisting of lower hills, middle and higher hills, alpine zones, and snowbound land; the highest elevation of 8583 meters being the top of the Mt. Kangchendzonga. As per the recent India State of Forest Report 2017 the total tree and forest cover of the State is 3379 sq. km which is 47.62 percent of the total geographical area of the state. The composition of forest in Sikkim ranges from tropical Dry Deciduous Forests with Sal and its associates in the valleys of Teesta and Rangit to the Alpine Scrub and grassland in high altitude (State of Forest report, 2017). There are mainly five forest types in Sikkim namely sub-tropical, moist mixed deciduous, wet temperate, conifer and sub-alpine forest (State of Environment-Sikkim Forest, 2017). It is the only Indian state having five forest types and climate ranges from sub-tropical in the south to tundra in the north. Sikkim has been divided into four districts and each district has further been bifurcated into two sub-divisions for administrative purposes except the east district which has three subdivisions. Out of elevation ranging from 310 to 8583 meters the habitable areas are only up to the altitude of 2100 meters constituting only 20 percent of the total area of the state. The highest portion of Sikkim lies in its North West (Sikkim Urban Dynamics, 2013).

2.2 Methods

The study was conducted during the year 2016-2018 in 12 selected rice growing villages of the 4 districts of Sikkim which exhibits varied environmental conditions. A total of 37 farmers were interviewed randomly as respondents. After careful mapping of the rice growing areas in the state, the locations were purposively selected based on (a) long history of rice cultivation and (b) presence of elderly farmers who possesses experience in rice farming and Indigenous technical knowledge. From each selected location elderly and experienced farmers were contacted. The informal interview method was used for collecting information. Indigenous knowledge was documented with the help of group discussion and field visits. The field visits included collection/documentation of local landraces and farmers' interviews on local rice landraces, cultivation and utilization including various

various specialty and organoleptic traits as well as application for food or ingredients in various rituals and practices of the particular community. In addition to these farmers, local leaders and village level workers (VLWs) of the state Agriculture department were also consulted about the indigenous agriculture practice on rice landraces prevalent in the region. Apart from these sources, knowledge on rice cultivation were also collected from the secondary sources i.e. magazines and journals.

3. Results and Discussions

3.1 Collection of rice landraces.

Totally 74 traditional rice landraces (Table 1) were collected during the study. They represent significant portion of the recorded 77 rice landraces (Sharma *et al.,* 2016) from the Sikkim which were re-assembled after long gap during the present study. Based on the information collected, the rice cultivation practice in the state can be broadly categorized into two categories (i) direct sowing method (upland rice) and (ii) transplanting method. The later is very popular and widely practiced, while former is still in use in some places. These landraces are cultivated only by the primitive *Lepcha* tribe who are indigenous to remote *Lepcha* villages of *Pentong, Sakyong*, and *Tingvong* of upper Dzongu in North Sikkim, where age-old Jhum system of agriculture is still practiced by a few farmers (Fig. 3 a-d). The local rice landraces which are directly sown or upland rice (*Ghayadhan*) are *Kalo tukmar, Seto tukmar, Tukmorzho, Mumpupzho, Marbonzho, Chinizho and Kalo dharmali* (Fig 3e). Among the transplanted landraces, the most commonly cultivated ones under irrigated conditions includes *Thulo attey, Sano attey, Krishna bhog, Kalo nunia, Birinful, Doodhkatey, Kataka, Tulashi, Kalo dhan* etc, which are grown mostly below 1200 m asl. The cultivation of fine aromatic rice varieties like *Krishna bhog, Kataka, Tulashi, Kalo nunia* (Types I, II and III) etc. are confined to the low hill areas where temperature and humidity are on the higher side. Paddy cultivated at the middle hill is primarily short to medium grain type like *Attey, Phudungey, Sirkey, Taprey* etc.

Amongst all the landraces, *Krishna bhog* and *Attey* are widely popular and found to be cultivated in all the four districts from foothills to about 1500 m asl. They both possess very good cooking quality, taste and palatability and are reported to be resistant to several diseases (Sharma *et al.,* 2015). *Krishna bhog* is one of the premium rices which is highly sought after for its pleasant aroma and used in the preparation of special dishes like *kheer, pulao*, *dhakaney* (prepared with milk and roasted rice) and religious offerings. Among the local landraces, *Attey* is popular and occupies large cultivation area in every part of state. There are two variants of *Attey* known viz. *Thulo attey* and *Kanchi* (Sano) *attey* of which *Thulo attey* is more accepted. Its grain type is short and bold and length varies from 8-10 mm. The color of the hull is brown/light yellow and grain colour is white with very good cooking qualities. It has medium bold white kernel of non-glutinous nature and shows good expansion after cooking. The keeping quality of cooked rice is better than improved varieties. Its taste and palatability are considered superior. Even at low nutrient application, *Attey* landraces perform much better than High Yielding Varieties HYVs. The farmer's preference of this variety is due to its palatability, non formation of chaffy grain and higher biomass.

Among the upland rices, *Tukmorzho,* with pink starch has been in cultivation since ages by the *Lepcha* community of Dzongu, North Sikkim. The germplasm has been conserved through generations and is the most preferred rice in all the rituals of this tribe. The pink starch as such is believed to have high nutraceutical value and is consumed by women during and after the pregnancy. It is believed to heal anemia. It is presumed that this rice has high content of iron and folic acid.

Kalo nunia or small Basmati is another distinct landrace and is the only aromatic rice among the short bold grain types with black colored husk, which is distinct for all other rice varieties. It is considered as the best short grain aromatic rice in this region. It has a delicate aroma, taste and texture. The cost of production is extremely high because seeds of pure lines are not available easily and the farmers cultivating the one are reluctant to spare them. The rice variety typically grows in the tropical areas having temperature above 20°C. *Birinful* is one more special class of aromatic rice with highly conspicuous awns. The variety is popular for its unique aroma, good cooking qualities and excellent palatability for preparation of many sweet dishes. In our study, significant variability was recorded among all the landraces for their qualitative traits such as aroma, seed coat color, kernel pigmentation, grain morphology, anthocyanin coloration on plant parts and awnness which is in consistence with earlier observation (Sharma and Rai, 2012). The residual of the crop (*Paraal*) is the main source of animal fodder during the dry winter season

Table 1. Details of rice landraces collected and their collection locations

Aromatic Rice landraces					
Sl. no	**Local name**	**Place of collection**	**Sl. No.**	**Local name**	**Place of collection**
1	*Basmati*	Gerethang (W.S.)	12	*Krishna bhog I*	Rumtek (E.S.)
2	*Basmati I*	Nandok (E.S)	13	*Krishna bhog II*	Tareythang (E.S.)
3	*Basmati II*	Rumtek (E.S)	14	*Rajabara*	Budang (W.S.)
4	*Bhagey tulashi*	Saureni (E.S.)	15	*Ram bhog*	Tareythang (E.S.)
5	*Birinful*	Gerethang (W.S.)	16	*Ramjeera*	Gerethang (W.S.)
6	*Kalimpongey*	Saureni (E.S.)	17	*Rudhua*	Saramsa (E.S.)
7	*Kalo nunia I*	Saramsa (E.S.)	18	*Sano tulashi*	Aho (E.S)
8	*Kalo nuniaII*	Tintek (E.S.)	19	*Shyam jeera*	Daramdin (W.S.)
9	*Kalo nuniaIII*	Daramdin (W.S.)	20	*Timburey*	Daramdin (W.S.)
10	*Kalo dhan*	Budang (W.S.)	21	*Tulasi*	Bering (E.S)
11	*Kataka*	Bering (E.S.)			
Non- Aromatic rice landraces					
22	*Auti dhan*	Dalapchand (E.S.)	45	*Lama dhan*	Ramthang (N.S)
23	*Bhotangey*	Bering (E.S.)	46	*Mailey attey*	Tintek (E.S)
24	*Champa*	Daramdin (W.S.)	47	*Manipuri*	Budang (W.S.)
25	*Champasari*	Turuk (S.S.)	48	*Mansarey*	Daramdin (W.S.)
26	*Charingrey*	Chota-Singtam (E.S.)	49	*Marshi*	Daramdin (W.S.)
27	*Chewrey dhan*	Budang (W.S)	50	*Masari*	Daramdin (W.S.)
28	*Chirakhey*	Bering (E.S.)	51	*Masino*	Daramdin (W.S.)
29	*Damrojho*	Ramthang (N.S)	52	*Masuley*	Melli (S.S.)
30	*Dhansey*	Rumtek (E.S.)	53	*Namphokey*	Sripatam (S.S)
31	*Doodhkalami*	32 Mile (E.S.)	54	*Nepalzho*	Lingthem (N.S)
32	*Doodhkatey*	32 Mile (E.S.)	55	*Nepalia*	Phodong (N.S)
33	*Dorakhey*	Dalapchand (E.S.)	56	*Panbhara*	Daramdin (W.S.)
34	*Fauryal*	Dzongu (N.S.)	57	*Phudungey*	Assam Lingzey (E.S.)
35	*Fourey*	Bering (E.S.)	58	*Pountain*	Daramdin (W.S.)
36	*Japani*	Budang (W.S.)	59	*Sano attey*	Rumtek (E.S.)
37	*Jasuda*	Rhenock (E.S.)	60	*Sano tulashi*	Aho (E.S)
38	*Jhapaka*	Rhenock (E.S.)	61	*Seto dharmali*	Sang (E.S)
39	*Jogi dhan*	Dalapchand (E.S.)	62	*Sirkey*	Tintek (E.S.)
40	*Kaanchi*	Dentam (W.S.)	63	*Taichung*	Ramthang (N.S)
41	*Kagey*	Reshi (E.S.)	64	*Taprey*	Rumtek (E.S.)
42	*Kaltura*	Reshi (E.S.)	65	*Thamba*	Melli (N.S.)
43	*Khampti*	Budang (W.S.)	66	*Thulo attey*	Bering (E.S.)
44	*Lal baachi*	Daramdin (W.S.)	67	*Thulo tulashi*	Saureni (E.S.)
Upland rice landraces					
Sl. no	**Local name**	**Place of collection**	**Sl. No.**	**Local name**	**Place of collection**
68	*Chinizho*	Dzongu (N.S.)	72	*Marbonzho*	Dzongu (N.S.)
69	*Dharmali (Kalo)*	Pentong, (N.S.)	73	*Seto tukmar*	Sakyong (N.S)
70	*Kalo tukmar*	Sakyong (N.S)	74	*Tukmorzho*	Dzongu (N.S.)
71	*Mumpupzho*	Dzongu (N.S.)			

E.S. East District of Sikkim, W.S. West District of Sikkim, N.S. North District of Sikkim, S.S. South District of Sikkim

3.2 Documentation of Indigenous Traditional Knowledge (ITK).

The information on indigenous technical knowledge associated with the rice cultivation in Sikkim and the rationale behind their uses are depicted in Table 2. Following are some important ITK associated with the various stages of rice cultivation in Sikkim.

3.2.1 Selection of seeds

For selecting and conserving healthy seed for next sowing, the bold grains from the field having healthy crop growth are selected in advance and proper care is provided to protect the field from pest and bird attacks etc. During harvesting, the selected plants are carefully sorted and later used for manual threshing. The threshing yard is prepared by uniform spreading of a mixture of cow dung and mud paste in the area earmarked regularly for threshing (*khalegara*). The selection of seeds is also done on the threshing floor. Manual threshing is the only practice followed in Sikkim. While threshing, bold seeds which are shattered by the first two beatings are collected. This process is found to be effective in separating the partially filled and diseased grains. Farmers here believe, grains selected by this process have better vigour, too.

3.2.2 Preparation of seedbeds and land

The site selection for the nursery is generally near the assured source of irrigation. The land is ploughed twice in the dry condition; cut the terrace wall to incorporate the debris and unwanted plant materials into the field. This debris gradually decomposes to provide nutrients to the soil. The first ploughing is followed by the second after two weeks. During this interval, the weeds sprout in the rice field. Hence during the second ploughing, farmers expect to eliminate all of them.

Determining the appropriate time for land preparation for nursery/seedbed (*Biyaar*) (Fig 1e) is based on the onset of south-west monsoon in the month of June and also during the harvesting time of maize planted in the rice field. It's a common knowledge of the farmer that timely sowing is the best non-monetary input. If sowing is delayed by one week after July, the flowering phase and maturity phase are delayed or extended by another month. The ideal time determined for nursery rising are (i) High hills: 1st week of May to 1st week of June, (ii) Mid hills: 2nd week of May to 2nd week of June and (iii) Low hills June to early August. The nursery area required to provide seedlings for transplanting one hectare is roughly 1/10 hectare and seed rate 50 kg/ha. To ensure rapid and uniform germination, seeds are soaked for 24 hrs in clean water which is drained thereafter and the seeds are incubated in warm, moist place for 36-48 hrs to let them sprout for sowing. The Chettri community of lower Bering has a traditional way of soaking the seed with a gold ornament overnight which they believe will yield a good harvest. Similarly, the farmers of *Lingthem, Dzongu* give hot water (50-52^{o}C) treatment to render the seeds disease free.

3.2.3 Water management techniques

Rice seedlings, raised in nurseries are transplanted on to the irrigated terraces and field remains almost submerged throughout the growing season and water generally drains out through a single outlet of the field. For better water conservation and management, in the hilly terrain of Sikkim, farmers build levelled terraces depending upon the slope which even prevent soil erosion. The benches and terraces are watered through perennial spring, tapped from the higher elevation (Fig 1a). The water is collected into small gullies commonly known as '*Kulo*' in local language. The water from this *kulo* is taken to irrigate the rice fields. Most of the time, a single *kulo* has to be used by many farmers and needs to be maintained regularly for uninterrupted flow from distant places. The natural course of water is frequently not disturbed to drain out the excess water. The surface flow of water from one terrace to another is managed in such a way that suspended solid particles remain in the terraces only. However for indirect sown upland paddy, no irrigation is required. In this case, paddy is cultivated on the inclined hills utilizing rainwater.

3.2.4 Method of rice planting

All the respondents reported that the transplantation from nursery to field takes place during the month of June-July (*Aasar* as per local Hindu calendar). Transplanted rice is cultivated on meticulously designed terrace fields (Fig 1a). Two wet ploughings with the country plough (Fig 1c, Fig 4a) (*Halo*) followed by wooden levelling beam (Fig 1d, Fig 4b) (*Dadhey*) for puddling and levelling of field is performed to prepare the land for transplanting of 25-30 days old seedlings. Proper levelling of the paddy filed is done so that water control could be maintained throughout the crop season. Terraces are finally levelled by wooden hand leveller (fig 4 d & e) (*kodalo & Phyauri*) to maintain the water level in the field throughout the crop season.

After attaining the optimum stage of seedling i.e. 4 leaf stage or about 21 to 25 days after sowing in short duration varieties and 30-35 days sowing in case of long duration varieties, they are lifted carefully to minimize root injury and kept in shade to avoid water losses. If the soil of nursery becomes hard, then seedlings are uprooted in the presence of water. Transplanting is done manually (Fig 1f) and row and plant spacing is

not maintained. Farmers inter-crop rice with a traditional variety of soya bean [*Glycine max* (L.) Merrill], rice bean [*Vigna umbellata* (Thunb.) Ohwi et Ohasi] and black gram (*Vigna mungo* L.) on the bunds (Fig 1h). A dedicated rice plantation festival of "*Aasar Pandra*" or "*Ropain*" is celebrated in the state. The festival has a great significance for the local farmer as it is the time of year when farmers plant new seedlings in their filed wishing to grow quintals of rice from kilos. This period is considered as the optimal time for sowing of rice seedlings which will determine the panicle initiation time during the month of October when the sky generally remains clear and sunny thereby avoiding cold and dry month of November or rainy months of mid-August to September (*Bhadau* as per Hindu calendar). It has been documented that low temperature and high humidity generally causes the development of insects and pests in rice field (Singh and Sureja, 2011).

The rainfall pattern is one of the important factors for determining the productivity of rice. Accordingly, local names have been assigned to the rainfall pattern called *Jhari* (Continuous rainfall for two to several days). Such *jharis* are very crucial for almost all rain-dependent agriculture. All total 9 *jharis* have been documented; they are Titey, *Naurethey jhari, Sisney jhari, Bhadaurey jhari, Sauney jahri, Makurey jhari, Bhangeri jhari, Kartikey jhari and Sohrasaradey jhari* (Sharma and Rai, 2012). Every *jhahri* has its own significance in the agricultural system; however for rice cultivation *Naurethey* and *Bhadaurey jhari* are most important. *Naurathey jhari* occurs during the month of September and October, before Dusshera festival as during this time heading stage of paddy initiates and requires plenty of water in the rice field. It is believed that this rain will determine the rice productivity for that year. Similarly, *Bhadaurey jhari* occurs during the month of *Bhadau* (15 July-15 August) immediately after paddy is transplanted in the main field. During this time the perennial and season spring water source swell up owing to the continuous rainfall providing enough water to the rice field (Sharma and Rai, 2012).

Fig.1. Low land rice cultivation practices in Sikkim (a) Terrace field, (b) Bunds clearing and mud slicing (c & d) Ploughing and levelling (e) Seedbed/Nursery, (f) Transplantation from nursery to the main field, (g) Manual weeding and (h) Grain filling stage and intercropping of Rice bean along the bunds.

Fig. 2. Genotypes collected during the field visits.

3.2.5 Soil fertility management.

In Sikkim, in order to manage soil fertility, two traditional approaches are followed alongside previous cropping (i) intercropping of rice bean along the ridges/bunds of terraced field and (ii) rearing the cattle herds in the field. The purpose is to provide nutrients to the soil. Legume plants in particular improve the nitrogen condition in the soil and can grow under the low moisture content (Dey and Sarkar, 2011). During the field preparation stage, the topsoil from these bunds containing the nitrogen-fixing *Rhizobium* bacteria are sliced back to terraces for rejuvenating the fertility, and new soil is put on the bunds for planting the rice bean crops every year (Fig 1b). Rice bean is a non-determinate type of legume which enriches the soil by adding a large amount of foliage and fixes more nitrogen as compared to other legumes. During harvesting time, the crop stalk is cut at 4-6 cm above the ground level, which also caters to more organic matter in the field. Since there are enough biomass and forage for cattle to feed the cattle dung and urine provide the essential nutrient to the soil.

Fig. 3. (a) Typical field view of upland rice cultivation, (b) Land preparation for the cultivation of paddy, (c & d) Seedling stage & (e) Seven upland rice varieties of Sikkim (*Kalo tukmar, Tukmorzho, Chinizho, Marbonzho, Mumpupzho, Dharmali & Seto tukmar*)

Fig 4. Tools used for rice cultivation (a) Country plough (*Halo*) (b) leveller (*Dadhey*) (c) *Aanau* (d) *Kodal*, (e) wooden hand leveler (*Phyauri*) (f) *Kaata* (g) *Kachiya* (h) Traditional rain protector (*Ghoom*) and (i) *Hasiya*

3.2.6 Harvesting and threshing

The upland rice is harvested using a knife (Fig 4g & i) (*Kachiya & hasiya*) panicle by panicle. Handfuls are tied together into bundles for initial storage and drying in the farm hut. When convenient, the rice bunches are taken down and thrashed. In case of lowland rice, crop is harvested close to the ground using sickles and left in the field for 2-3 days for drying, after which, it is tied in to bundles. These bundles are carried to threshing yard or *khalegara*, where they are stacked on a wooden platform, locally called *Kunieu* for 2 to 2.5 months. These bundles are then threshed to obtain grains by beating against a wooden plank. The straw is also trodden under the feet of bullocks to obtain the remaining grains from the panicle.

Table 2. Different ITKs in rice cultivation documented from Sikkim.

Sl. No	Description of identified ITKs	The rationale behind the use of ITKs
Seed selection, treatment, and germination		
1	Fields having healthy growth are selected in advance and proper care is given to protect the selected plot from animal and pest attack.	Healthy grains will be selected for next year sowing; the seeds selected by this process are healthy and have high vigour.
2	Seeds collected from the first two thrashings by the manual method are used for selection of next year's seeds.	To remove partially filled unfertile as well as diseased grains.
3	Hot water treatment to seeds at 50-52^{o}C for 10-12 minutes.	Enhances germination and renders seeds disease free.
4	Overnight soaking of seeds with gold ornament.	Believed to yield a good harvest.
Rising of seedlings		
5	During seedbed preparation, land is pulverized along with the stubbles and weeds and allowed to decompose.	Seedlings grown this way facilitate easy uprooting as they do not penetrate deep into the soil. Uprooted seedlings contain very less amount of soil in their roots.
6	Ash sprinkled over nursery bed before the broadcasting of seeds.	Facilitates quick germination and easy uprooting of seedlings.
7	In case of upland rice like *Tukmar* and *Tukmorzho* seeds are directly sown into the cleared hill slopes.	The hardy seeds are expected to germinate and survive based on natural resources.
8	Most of the landraces from low hills are grown on nursery beds in wet conditions.	Growing seedlings in wetlands facilitate quick and vigorous growth as seedlings do not suffer water stress due to drought.
9	*Chinizho* (upland rice) collected from *Pentong* village is cultivated in the marshy fields, where the field is ploughed to overturn the marshy vegetation and seeds are directly sowed in a field.	As the field remains wet all the time seed germinates and grows using natural water availability.
Main field preparation		
10	Clearing, slashing and burning of vegetation from the sloppy hills with the initiation of monsoon rain in case of upland rice cultivation.	This practice allows the ash to fertile and disinfect the soil before planting.
11	Ploughing with initial irrigation in case of low land types well ahead of final puddling and keeping the field as such for 15-20 days after levelling until some excreta of earthworm are seen on the soil surface.	This practice allows growth of earthworm which facilitates decomposition of stubbles and weeds thereby making the soil more fertile both with decomposed materials and earthworm excreta.
12	Cutting/slicing the bund edges and walls of the terraced field with local hoes.	Lessens weed growth around the borders and reduces pest population by disease spreading insect vectors.
13	During land preparation bunds are plastered with mud paste from the wet field.	Weed growth is suppressed and runoff rainwater as well as irrigated water is reduced.
Fertility management		
14	Burning of stubbles followed by hand ploughing	The ashes produced as a result of burning of stubbles add to

	in case of upland rice.	soil fertility. Besides pest and their eggs gets burnt and further pest population in the subsequent crop becomes less.
15	Intercropping with a common rice bean along the bunds of terrace field.	During field preparation, topsoil from those bunds containing the nitrogen-fixing *Rhizobium* bacteria are sliced back to rejuvenate the fertility and improves the nitrogen level in the soil.
16	Rearing of cattle herds in filed after harvest.	Since there are enough biomass and forage for cattle to feed, the cattle dung and urine provides the essential nutrients and possible disinfection to the soil.
Transplanting method		
17	In upland rice cultivation seeds are sown directly into furrows instead of transplanting.	To provide required temperature for germination of seeds and to avoid runoff losses of seeds in torrential rains.
18	Some upland rice varieties are transplanted directly to the seedbeds prepared at hill slopes to terraced fields.	The varieties like *Marbonzho* and *Chinizho* are cultivated both in dryland and can be transplanted even in wet fields.
19	Uprooting and transplanting of 25-30 days old seedling from nursery to the main field during the month of *Asar* (June –July).	This practice is called ad *Ropain* in the local language. It allows the seedlings to attain height to suit the depth of water in the main field. Also, the rice transplanted during this time caters to the timely initiation of panicle at a suitable time and temperature, reducing the infestation of insects and pests.
20	Instead of discarding the leftover seedlings they are kept in a cluster in one of the corners of the main field immersed in water.	In the event of the death of seedlings immediately after transplanting, these seedlings can be used for gap filling.
Water management		
21	Water is channelized to the rice field from nearby perennial spring water tapped from the higher elevation.	This practice will provide continuous water supply to the terraced field made on hill slopes, water generally drain out through the single outlet of field.
22	Irrigation with bamboo pipes by splitting the bamboo into two equal halves vertically and removing the nods which act as a pipe for carrying water.	Since bamboo is widely available, bamboo pipes so prepared reduces the loss of irrigation water during transit and they are cheaper in comparison to the poly pipes.
Plant protection		
23	Bamboo sticks and other trees are cut and erected in the nursery as well as the main field.	Birds perch on the branches and sticks and acts as predators of insects present in the crops.
24	Plantation of drumsticks trees (*Moringa olifera* Lam.) along the rice field.	The leaves, barks etc. of the drumsticks tree checks the infestation of stem borer as it is known to have high pesticidal properties.
25	Spraying of fresh cow dung solution (approx. 1 kg raw cow dung in 10-12 L of water).	Cow dung solution controls bacterial leaf blight to some extent. Further, the crop is protected from cattle as they do not graze upon cow dung treated crops.
26	Crabs, frogs or toads are killed and hung from bamboo sticks erected in a crop field in different places.	The peat, especially bugs, attracts and crowd over the dead crabs/frogs instead of sucking soft grains.
27	Burning of firewood straw etc. in an around the field at night.	Various pests, particularly bugs and hoppers, jump down on to the fire and get destroyed.
28	Hanging of damaged videos and audiotapes over the nursery bed of rice just after broadcasting seeds and in the main field in the maturity of the crop.	The glittering/shining property of tape drives away the birds and prevents the birds from feeding the grains.
29	Keeping scare crow made up of thatch in the nursery as well as the main field.	It frightens birds and prevents the birds from eating up the grains.
30	Hot water treatment of seeds at 50-52°C for 10-12	Reduces the spreading of brown spot diseases of rice.

	minutes.	
31	Field sanitation and burning of straw and stubbles in the field and early sowing of seeds.	Reduces the spreading of blast diseases.
32	Use of Tulsi (*Ocimum* sp.) leaf extract prepared by boiling approx 25 gm of leaves in 1 L of water.	Spray reduces spreading of blast diseases.
Post-harvest practices		
33	Leaves of neem (*Azadirachta indica* A. Juss.), hardi [*Curcuma longa* (L.)], ginger (*Zingiber officinale* Roscoe), Bhojo (*Acorus calamus* L.*)*,bakainu leaf (*Melia azedarach* L.), and curry leaf [*Murraya koenigii* (L.) Spreng.]. are kept with rice grains in granaries and other storage structures.	The disagreeable odour as well as insecticidal properties of these leaves keeps away the storage insects pests from causing damage to the grains. All the mentioned plants have proven pesticidal and insecticidal properties.
34	Storing grains in locally made structures called *Bhakhari* and *Kothe* prepared from the bamboo and plastered with raw cow dung and mud mixed paste.	Grains stored in these structures are not easily damaged because these structures prevent most of the pests to reach grain from outside.
35	Grains for seed purposes are stored in gunny bags placed over the fire place.	The smoke from the burning of firewood prevents the infestation of any pests and insects.

3.2.7 Storage and Post-harvest techniques.

In Sikkim, most of the farmers have minimal land holdings, whatever produced are used for household consumption and planted for next year (Lamichaney *et al.,* 2019). Hence, the indigenous knowledge in storage aids structures is most important as the entire agricultural produce is stored at home only. Further, due to heavy rainfall (about 2731 mm annually), storage of grains is a huge challenge. An extensive documentation by Lamichaney *et al.,* (2019) on the indigenous methods of grain storage of the *Lepcha* and *Limboo* communities of Sikkim reports that indigenously made bamboo baskets, mud structures from the locally available materials have successfully stored the crops, protecting it from storage pests, insects and rodents. In Sikkim, bamboo is the cheaply available commodity and low-cost raw material and thus every farmer prefers to use bamboo prepared storage structures. Some of the indigenously prepared bamboo storage structures are (i) *Bhakari* (Fig 4a) (ii) *Kotha/Kothe*. Apart from these bamboo structures, some farmers also have "*Dhikutis*" (Fig 4b) which means storage in Nepali. *Dhikuti* is made up of four side box basically constructed with wood and a wooden lid having a capacity of more than 400 kg of grains. It is the most preferred grain storage method. Whereas *Bhakari* and *Kothe* are woven bamboo structures prepared by rolling the closely knitted bamboo mat, which is smeared with cow dung and mud to seal the holes for safe storage of seeds and grains. In some cases, mustard seed pressed cakes (*Peena*) are also used for plastering the bamboo mat which is believed to have anti-insecticidal properties and increase the durability of the structures. Many locally available additives are also used to enhance the life of seeds stored. Most common of them are the neem (*Azadirachta indica* A. Juss.), hardi [*Curcuma longa* (L.)], ginger (*Zingiber officinale* Roscoe), Bhojo (*Acorus calamus* L.*)*,bakainu leaf (*Melia azedarach* L.), and curry leaf [*Murraya koenigii* (L.) Spreng.]. These plants are known to have anti-microbial and insecticidal properties (Talukdar *et al.,* 2012; Nathan *et al.,* 2006; Carpinella *et al.,* 2007; Faraga *et al.,* 2011). All the storage structures are easy to use and construct and have proved to be yielding satisfactory results. The traditional mill called *Dikhi*, constructed using big wooden trunks (Fig 5c) now rarely exists, farmers now prefer to take their paddy to electric mills where the milling cost is about 2-5 Rs./Kg of paddy.

4. Personal observations and recommendations

We deliberately chose elderly farmers as respondents for our study. The underlying belief was that they are the one who remembered and authentically used indigenous technologies. From our interactions with farmers from all across the state, this presumption was found to be valid and young farmers showed greater inclination towards improved technologies, if not downplayed the older ones. In the light of this, it is cautioned that many indigenous rice landraces and their farming technologies in Sikkim might disappear with the time as they are passed on through tradition. Such observation is already part of many earlier reports (Zuberi, 1997; Kambewa *et al.,* 1997; Anonymous. 1989 and Anonymous, 2000).

Fig 5. (a) *Bhakari,* (b) *Dhikuti* and (c) Tradition mill (*Dhiki*)

Additionally, Sikkim being fully organic state, adoption of a modern technology and package of practices for agriculture could be challenging to farmers as use of chemical fertilizers etc. as needed by the modern agriculture methods are not allowed. The major constraint is non-availability of research-based proven/reliable indigenous technical knowledge which can act as an alternative to modern methods in agriculture. Hence, extension agencies should bring feedback to the knowledge of research workers for listing and validating suitable indigenous technical knowledge in agriculture on sound scientific principles. Further, analysis of the indigenous technical knowledge for their productivity, suitability, sustainability and cost-benefit ratio should be undertaken by a multidisciplinary team including agricultural researchers with the involvement of farmers for any interventions possible. Field trials needed to be conducted to test the documented Indigenous Technical Knowledge and to develop a package of indigenous practices for use by the farmers and demonstrations.

Finally, many old farmers expressed that in their younger days they had seldom witnessed the pests and disease infestation owing to local resistant varieties. Now, when the local varieties do not find any place in the set of modern practices, new pests and diseases ought to be controlled by modern techniques only. Hence, even if an individual farmer would decide not to adopt a modern package of practices, he/she may not strictly remain to abide by his/her decision. Deforestation and ruthless destruction of trees have adversely affected the flora and fauna in the state. Plants used for the preparation of medicines or for manure are becoming scantily available. Further, their loss is also affecting the ecosystem, breaking the food chains and keeping the wild animals and birds deprived of their shelter and food which ultimately resulted in the attack on their rice fields. Hence, in light of these facts, it will be a wise step to determinately conserve the flora around Sikkim Himalayan region as already suggested in different contexts by several earlier reports (Anonymous, 1997 & Ghotage, 1997).

5. Conclusion

This study found Sikkim has rich repertoire of rice landraces which can provide novel genetic resources and genes for breeding programs after due characterization. However, urbanization, industrialization and introduction of improved varieties has rendered most of the rice fields now being rapidly converted into developmental projects which have

resulted in rapid extinction of many landraces. Cultivars such as *Botangey, Dharmali, Tukmar, Chinizho, Mumpupzho, Marbonzho, Taichung, kalo dhan Tukmorzho, Japani, Marshi, Sirkey, Birinful*, are found rarely now and are cultivated at single locations only by few farmers and are facing acute genetic drift as reported in previous studies as well (Rahman and Karuppiyan, 2011).

Further, Indigenous Technical Knowledge pertaining to agriculture practices has strong roots in Sikkim. This study documented 35 Indigenous Technical Knowledge related to paddy cultivation, which may serve as alternatives to modern technologies. If proper attention, identification and documentation of ITKs are done without any prejudice, further screening and verification can be done to ascertain their actual utility. If the policymakers initiate steps to promote useful traditional knowledge among the farming community after desired modifications and refinement, it will help in bridging the gap between two knowledge systems and help in restoring economy and already fragile ecology of this beautiful Himalayan state.

6. Acknowledgment

The authors are thankful to all the respondents of Sikkim for sharing and providing information regarding the ITKs on local landraces of rice and also providing seeds for further study.

References

Anonymous (1989). Constraints in adoption of recommended technologies for cultivation of Nagali by the farmers. *Research Council Report*, Department of Agricultural Extension, College of Agriculture, Dapoli, District Ratnagiri, Maharashtra.

Anonymous: Community-based research on local knowledge system (1997). The ANTHRA Project on Ethnoveterinary research. *Ethnoveterinary medicine: Alternatives for Livestock Development. Proceedings of an International Conference* held in Pune, India, (Eds. Mathias, E., Ranganekar, D.V. and McCorkle, C.M., 1999) on November 4-6, 1997, Volume 1: selected papers. *BAIF Development Research Foundation*, Pune, India.

Anonymous (2000). Documentation of indigenous technical knowledge. *Report*, Konkan Krishi Vidyapeeth, Dapoli, District Ratnagiri.

Carpinella MC, Miranda M, Almiron WR, Ferrayoli CG, Almeida FL and Palacios SM (2007). In vitro pediculicidal and ovicidal activity of an extract and oil from fruits of *Melia azedarach* L. *J American Academy of Dermatology*, 56, 250−256.

Chhetry GKN, and Belbahri L (2009). Indigenous pest and disease management practices in traditional farming systems in northeast India. A review. *J. Plant Breeding Crop Sci.* 1(3) 28-38.

Dey P and Sarkar AK (2011). Revisiting indigenous farming knowledge for Jharkhand (India) for the conservation of natural resources and combating climate change. *Indian J Traditional Knowledge* 10 (1) 71-79

Economic Survey of Sikkim, State planning commission, Government of Sikkim (2006-2007).

Economic Survey of Sikkim, State planning commission, Government of Sikkim (2013).

Food Supply and Agriculture Development Department (FSADD) and Horticulture and Cash Crop Development Department (HCCDD) Govt. of Sikkim (2010). "Vision for holistic and sustainable organic farming in Sikkim- the Future thrusts".

Faraga M, Ahmed MHM, Yousefa H and Abdel–Rahmans AA (2011). Repellent and insecticidal activities of *Melia azedarach* L. against cotton leafworm, *Spodoptera littoralis* (Boisd.). *Zeitschrift fur Naturfoschung* 66, 129−135.

Ghotage N, Summary of the healers' workshop (1997). *Ethnoveterinary medicine: Alternatives for Livestock Development. Proceedings of an International Conference* held in Pune, India, (Eds. Mathias, E., Ranganekar, D.V. and McCorkle, C.M., 1999) on November 4-6, Volume 1: selected papers. *BAIF Development Research Foundation*, Pune, India.

Kambewa BMD, Mfitilodze MW, Huttner K, Wollny CBA and Phoya RKD (1997). Ethnoveterinary medicine: Alternatives for Livestock Development. *Proceedings of an International Conference* held in Pune, India, (Eds. Mathias, E., Ranganekar, D.V. and McCorkle, C.M., 1999) on November 4-6, Volume 1: selected papers. *BAIF Development Research Foundation*, Pune, India

Lamichaney A, Chettri PK, Mukherjee A, Maity A and Shubha K (2019). Indigenous method of grain storage followed by the *Lepcha* and *Limboo* tribes in the Himalayan tract of Sikkim, *Indian J Traditional Knowledge,* 18 (4) 769-774

Nathan SS (2006). Effects of *Melia azedarach* on nutritional physiology and enzyme activities of the rice leaf folder *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae). *Pesticide Biochemistry Physiology,* 84, 98–108.

Portel BK (2015). *Economics of organic crops and food crops in Sikkim,* (Mphil Thesis, Sikkim University),

Rahman H, Karuppaiyan R, Agro biodiversity of Sikkim. (2011). In: M.L. Arrawatia and Sandeep Tambe (eds) Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot. Gangtok, Sikkim: Information and Public Relations Department, Government of Sikkim, p 403-426.

State of Environment-Sikkim (2007). Forest Environment & Wildlife Management Department Government of Sikkim

Singh RK and Sureja AK (2008). Indigenous knowledge and sustainable agriculture resources management under rainfed agro-ecosystem. *Indian J. Traditional Knowledge* .7 (4) 642-654

Subba J R 2009. Indigenous knowledge on bio-resource management for livelihood of the people of Sikkim, *Indian J Tradit. Knowl.* 8 (1) 56-64

State Profile of Sikkim, Directorate of Census Operations, Sikkim series-12, Part XII B (2010-2011).

Sharma G and Rai LK, Climate change and sustainability of agrobiodiversity in traditional farming of the Sikkim Himalaya (2012). In: ML Arrawatia and S Tambe (eds) Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot. Gangtok, Sikkim: Information and Public Relations Department, Government of Sikkim, pp 193-218.

Singh KK, Gaira KS, and Rai LK (2011). Agricultural scenario vis-à-vis the pollinator elements of the Sikkim Himalayan region. In: ML Arrawatia and S Tambe (eds) Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot. Gangtok, Sikkim: Department of Information and Public Relations, Government of Sikkim pp 429-442.

Sikkim Urban Dynamics (2013). Urban Development and Housing Department, Govt. of Sikkim.

Sharma L, Pradhan A, Bhutia KD, Tamang DL and Bhutia SG (2015). Local crop germplasm and landraces diversity in West Sikkim. *J Agric Technol* 2 (1&2) 57-59

Sharma G, Partap U, Sharma E, Rasul G, and Awasthe RK (2016). Agrobiodiversity in the Sikkim Himalaya: Sociocultural significance, status, practices, and challenges. ICIMOD Working Paper, Kathmandu: ICIMOD

State of Forest report (2017). Forest Survey of India, Ministry of Environment & Forests, Government of India.

Talukdar RK, Barman S & Hussain A (2012). Documentation and perceived rationale of Indigenous Technical Knowledge (ITK) utilized in Boro rice cultivation by farmers of Kamrup district of Assam, *J Academia-Industrial Research,* 1 (7) 412-418.

Zuberi MI (1997). Present state of the ethno veterinary system in northwestern Bangladesh. *Ethnoveterinary Medicine: Alternatives for Livestock Development. Proceedings of an International Conference* held in Pune, India, (Eds. Mathias, E., Ranganekar, D.V. and McCorkle, C.M., 1999) on November 4-6, Volume 1: selected papers. *BAIF Development Research Foundation*, Pune, India.