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ITKs for land use and water management in cold deserts of Ladakh valley in Jammu and Kashmir

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Abstract
The present study refers to the `Cold Deserts of Ladakh Valley which are characterized by subzero winter temperature (-40º to 20º C), high summer day temperature (up to 40 ºC) and annual precipitation less than 30 cm and that too in the form of snow. The inhabitants of Cold Desert have rich traditional knowledge concerning their crops, livestock and environment acquired through generational experience and experimentation with local resources. There is need to reinforce the traditional ethos and to build up a conservation society living in harmony with nature and making frugal and efficient use of resources guided by the best available scientific knowledge. Documentation of indigenous technologies of Cold Deserts with regard to land and soil management and water management, will go a long way in understanding, refining and assessing the technologies for the eco-economic rehabilitation of this otherwise fragile region. It will open the scope for scientific investigation of many farm technologies which are in vogue for the prosperity of the region and for which scientific explanations are not available. Participatory Rural Appraisal tools were used through detailed survey of the Ladakh valley. A total of 17 ITKs were identified for soil and water management.

Keywords: Cold deserts, Ladakh valley, ITKs, land use, water management

1. Introduction
The `Cold Deserts' in India cover an approximate area of 74,809 km^2 under 12 blocks (out of a total of 131 desert blocks in India) and are located in Ladakh (Leh and Kargil districts of Jammu and Kashmir) with some parts of Himachal Pradesh. These areas are closely associated because of their physiographic location beyond the Himalayan ranges of the Greater Himalaya. The `Cold Deserts are characterized by subzero winter temperature (-40º to 20 ºC); high summer day temperature (up to 40º C); annual precipitation less than 30 cm and that too in the form of snow. The cold desert areas are ecologically varied and biologically diverse, unique systems [1].

Inhabitants of Cold Desert have acquired rich knowledge concerning their crops, livestock and environment. This indigenous knowledge, developed and adapted as a result of years of practical experience, continues to be in the process of evolution for the urge of better and sustainable livelihoods. Only those adaptation practices and mechanisms that were acquired through generations and flexible to the needs of the natives have coexisted in the natural system till date in spite of such hostile conditions. But unfortunately, during the past few decades there has been an appreciable divergence from the traditional systems resulting in environmental degradation and decline in socio-cultural values. Indigenous knowledge is being overshadowed by modern culture and looked upon as backward, irrational, mostly labour intensive, lacking scientific reasoning and documentation. Regenerative and traditional environment-friendly practices were and are still being replaced by capital intensive modern technologies [2] [3].

Documentation of indigenous technologies of Cold Deserts with regard to land and soil management and water management, will go a long way in understanding, refining and assessing the technologies for the eco-economic rehabilitation of this otherwise fragile region [4]. It will open the scope for scientific investigation of many technologies which are in vogue for the prosperity of the region and for which scientific explanations are not available till date. It will further help in conservation of rich traditional knowledge hitherto practiced but now the most threatened resource of dry temperate region [5].

2. Methodology
Participatory Rural Appraisal tools have been used for the documentation of appropriate farm technologies in Cold Deserts.

Major emphasis has been put on semi-structural interviewing, focus group discussion, analysis group discussion and transect walk. In few cases, village meetings were also arranged. A close scrutiny of existing literature on traditional technologies was the first step before the collection of primary information. A gender specific perception was considered in information collection. A detailed survey of the Ladakh valley was made and nearly 250 farmers and locals were consulted through intensive touring and repeat surveys during the summers of last 5 years from 2012-2017 as during winters there is no accessibility and area is inhospitable.

3. Results and Discussion

The following ITKs in relation to and use and water management have been documented. These ITKS for land use and soil management have been refined by the locals through generational experience and are widely adopted. It has been tried to give scientific explanation wherever possible for the use of specific ITK with the consultation of experts.

3.1 Land distribution to meet ecological, economic and social needs

Availability of cultivable land is determined by the fertility status and moisture regime. The fields are dispersed on different altitudinal zonations. In some areas land consolidation has been done so that each family gets field spreading over upper, middle and lower reaches of the mountainous slopes. Religious sanctity is attached with the land distribution so as to minimize intra and inter village disputes. Pasture lands which are commonly found in the area are managed in accordance with the agro-climate conditions and the availability of farming labour. Rotational grazing is followed for optimum recouping of nutritive legumes and grasses. Organic manuring, a prime source of fertilization, is comprised of human excreta, animal dung, plant leaves and crop residue.

The distribution and management of land is in accordance with the social customs. On the one hand it reduces the societal conflicts and on the other provides opportunity for intensive land use for economic and ecological security by employing collective labour. Irrigation water is also regulated as per the aforesaid norm.

3.2 Management of grazing lands (*doksa*) for fertilizer needs and ecological challenges

Village grazing lands varying in size and number (from one to four) are called *doksas. T*he lower *doksas* have permanent huts, walled and roofed with stone, and with stone walled yards and pens for the stock while the remaining have circular stone walls for temporary shelter. These *doksas* are grazed by rotation depending upon their distance from the village. The management of *doksas i*s compatible with the ecological conditions of the area. These *doksas* serve as the buffering zones for grazing during early spring and late autumn when the higher grazing lands are snow covered. Rotational grazing is a common practice for sequential recovery of vegetation. These *doksas* also serve as the source for organic manure.

3.3 Grazing pattern for appropriate stocking rate

Grazing for different animals has been regulated for balanced and appropriate grazing pressure. Sheep, goats, cows and dzos spend their summer at Yimaling (high alpine pastures) in different specified zones. The animal movement down in the valleys is governed by their urge for mineral consumption. This type of grazing management helps in dispersing the grazing pressure to a larger area and providing sufficient time for recouping of vegetation. This also helps in natural resource management as the distant fodder resources are properly harnessed which otherwise would have gone waste.

3.4 Use of draught power as per the soil texture

Ploughing is generally carried out by *Dzos*, however, in sandy situations horses are employed for its speedy completion. In Turpuk area of Nubra valley, ploughing is done by a single horse. This practice speaks of land, labour and time management for large and scattered holdings. All type of available animals are put to use for draught purposes for speedy completion of work in the limited growing period.

3.5 Soil management by crop harvesting

Barley and wheat stumps are pulled up by hand along with the complete root system. Soil is softened by a light irrigation a day before. Wheat is often pulled up while standing but kneeling or squatting is practiced for barley. A large handful of these plants are beaten up against the legs (occasionally a small apron is worn) to shake off most of the earth. These bundles are then piled up like the tiles on the roof. The ears of the lower row are covered and protected from birds by the roots of the upper stacks. Very little plant material (stem and roots) is allowed to be left in soil as a protective measure against the soil borne diseases. The practice also increases the fodder resource for use in winter. The removal of soil from the roots is also indicative of their traditional expertise in soil management under harsh conditions.

3.6 Mixing of Soil from Cultivated Land Holdings with Night Soils for Organic Manuring

Broadcast of soil with human excreta over fields during winter months, is the only source of soil manuring in Ladakh region. Soil is collected from cultivated land holdings particularly from field bunds of subplots. The practice of collecting soil from cultivated lands and field bunds is superbly matched with the ecological setting of the area. This traditional practice helps firstly in easy ploughing during summer cropping and secondly, as claimed by farmers, as a check against any increase in soil quantity. The increased soil quantity, if added from outside source, may prove to be an erosion hazard or may even change the soil composition.

3.7 Use of Ash for Nutrient Recycling and Softening of hard soils

The inhabitants of the entire region use cattle dung, shrubs and bushes as the main source of fuel. Ashes available there upon, are mixed either with household waste or human excreta. Sometimes, ashes are also broadcasted in the fields. Mixing of ash with household waste and human excreta helps in nutrient availability and recycling. Ash primarily meets the deficiency of potash. Availability of phosphate is also ensured.

In Nubra Valley, hard soils are softened by putting ash obtained from cow dung, sheep/goat manure, fuel wood, etc. Through this practice, upper layers of soils are not only softened but their nutritional status is also improved. A mix of kitchen ash (FYM-Fuelwood) and goat manure is used in kitchen gardens (Nubra Valley) for growing potatoes. The spreading of this mix as organic manure increases the size of potatoes on account of the supply of optimum nutrients in otherwise nutrient deficit soils. Poultry manure and ash is used for increased vegetable production. This specific technology is used only in case of tomato, brinjal, capsicum

and cauliflower. Kitchen ash and poultry manure mix enhances vegetable production levels. Poultry manure and ash improves both the texture and fertility of the soil.

3.8 Use of goat manure in millets

Goat manure is considered by the inhabitants to be more nutritious. Goat manure when added to millet fields improves production. Goats are specially penned in these plots and fields. Goat manure improves not only the millet production but is also supposed to improve its taste. According to farmers vegetables grown with goat manure have longer keeping quality. It was further reported that it is easy to plough fields manured with goat excreta.

3.9 Use of broader plough in upper valleys

Ploughs are broadened by attaching wooden flat pieces to both sides of the iron blade. This indigenous plough is preferred over the one available in the market. This technology seems to have two-fold functions of saving labour and that of stabilizing the loose sandy strata in one plough action, suiting the small terraces.

3.10 Curved land ploughing for intensive land preparation, soil conservation and water retention

Ploughing is done by the inhabitants in a curved (sword like) manner from bottom to top of the sloppy land holdings. Ploughing land holdings in a sword like pattern ensures proper land preparation including the corners which otherwise would have remained unploughed. The ploughing of sloppy lands from bottom to top also helps in soil conservation as it may check the loosened soil strata falling from upper side to lower. The curved pattern is useful in maintaining water flow which otherwise gets wasted with sudden run off.

3.11 Conserving productive soil layer again wind erosion

It was observed that fields are irrigated in autumn so that the top layer is prevented from being blown away. In spring the moistened soil eases ploughing. The productive thin soil layer needs conservation against heavy wind erosion, a common feature of the cold deserts. This appropriate soil conservation technique also helps in easy and timely ploughing for meeting the exigency of short time and as a protection against wind erosion.

3.12 Contouring of sloppy lands: Ethno engineering for soil conservation

Farmers have developed this technology for cultivation of sloppy lands by constructing terraces comprising of plots and sub-plots through small stones. Stone wall fencing is also constructed for individual land holdings. Terracing of sloppy lands helps in conserving soil erosion. Uniform contouring is maintained for all the plots and sub-plots. This also helps to carry out other field operational including proper use of irrigation water for checking the surface run off.

3.13 Bio-fencing with Sea buckthorn (*Hippophae* spp)

There is a common practice to provide bio-fencing with sea buckthorn in Cold Deserts. The bio-fence of sea buckthorn being thorny in nature protects crops from stray animals. Its multipurpose utility as a nitrogen fixer, check against soil erosion, conservation of moisture, source of fuel wood and indigenous drug (rich source of vitamin C) makes it a promising plant for eco-economic rehabilitation of the region.

3. 14 Water Channels (Kuhls) for Irrigation

Glacial water which forms the prime source of sustaining life in the region is brought to the fields by making kuhls (water channels). Participatory management is employed for distribution of water. All disputes are amicably settled without hampering the water requirement of any field. *Kuhls* are built along the hill gradient for maintaining proper gravity for irrigation and running watermills. Flooding with glacial water on the one hand removes the toxic substances and on the other hand acts as a disinfectant against pathogens.

Means of irrigation in the region are *kuhls* (small water channels) drawn from streams/ *nallas*. The majority of the hamlets, which lie on the plateaus on the sides of Main River, get water from the streams which trickle down from the cliffs over-handing the plateaus. Another method is by collecting spring water into small reservoirs scattered at intervals on the high uplands and then drawing water from these ponds when required. A negligible portion of land is irrigated from the rivers themselves as they flow between steep banks. The fields lie either on naturally level plateaus on the banks of the torrents, or in terraces on the hill side wherever a channel can be brought from the nearest side stream ensuring safe side from the danger of its being damaged by avalanches or falling rocks. Some villagers have reservoirs above their cultivated lands, from which earth is taken to strew over the snow before the fields are raked in early summer. A few villages get water for irrigating their lands from some perennial torrents.

Irrigation channels are fairly long and considerable labour is spent every year in repairing them after snow melting. Usually all the beneficiaries get together to help in repairing them. If a person happens to be ill or otherwise absent then a substitute is provided by him and in some cases payment in lieu of a substitute is to be made. The repair of a water channel almost amounts to the construction of a new one, as the old ones are in many cases, wholly destroyed by avalanches. The water is led from field to field. This is a time tested community mode for sharing the glacial water by making *kuhls* for ensuing cent per cent irrigation in otherwise dry and porous soils.

3.15 Flooding of glacial water for higher crop productivity and irrigation scheduling

Water is brought in channels from glacial melts for irrigating the fields. Flooding the fields with the glacial melt for improving crop productivity is also common. The deposition of fresh silt with un-weathered minerals (especially lime) from glacier source of fresh water manages the soil fertility by removing toxic salts. The glacier melted water often below 2^{o}C temperature also protects the crops from different kind of diseases. Standardized irrigation schedule for different crops is followed.

3.16 Pang (*spang*) grass use for controlling seepage and side losses in water tanks and irrigation *kuhls*

Pang (*spang*) is used as inner linings of *Zings* (water ponds) and irrigation *kuhls* for checking percolation losses. The use of *spang* grasses growing profusely in Ladakh, for checking seepage of water explains its non-permeability properties similar to that of polythene sheet or cement lining. Its chemistry is required to be analyzed as the farmers claim its utility in water retention is far superior to the polythene/cement.

3.17 Ensuring proper irrigation through mud

Farmers regulate optimum irrigation to desired soil depth by inserting spade (*belcha*) into soil. If it is completely inserted (front portion) then it means land is properly irrigated.

Similarly, in few other cases, mud is thrown upside. Its split into pieces shows proper irrigation. This is a local practice to ascertain the optimum utilization of water and its penetration up to root-zone of the soil profile.

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