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Assessing the Potential of Indigenous Technological Knowledge (ITK) for Adaptation to Climate Change in the Himalayan and Arid ecosystems

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The present study was conducted with the objective of documenting and assessing the potential of indigenous knowledge towards adaptation to climate change covering a sample of 200 farmers, hundred each from Himachal Pradesh and Rajasthan representing Himalayan and Arid ecosystems respectively. Documentation of ITK was done using both primary and secondary source of information. In-depth study was designed by combining survey and anthropological approach of participant study. The major documented indigenous knowledge was '*mind*' cultivation, '*chal'* to harvest water, 'apple paste' to control diseases and '*siddu*' to protect from extreme cold in Himachal Pradesh. Similarly, the major documented indigenous knowledge of Rajasthan were–*Khadin'* farming system to manage drought, '*kanabandi*' to manage soil and wind storm, '*tanka*' to harvest water, '*jupka*' and '*kothi*' for storing the grain and feed, etc. Beside these, the people of both the ecosystems observed the movement of insects and animals (butterfly, ant, and termite) to forecast the rainfall and other climatic parameter. As the indigenous practices hold high potential to address the issue of climate change, these may be promoted after establishing their scientific validity and rationality.

Keywords*:* Climate change, Indigenous Knowledge, Adaptation

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Climate change refers to the change in the state of the climate that can be identified by changes in its mean and/or the variability of its properties and that persists for an extended period of time at least a decade[1]. The major impacts of climate change include irregular and erratic rainfall, heavy storm, cyclone, heavy fog, drought, loss of biodiversity, extreme weather, etc. Though climate change equally affect all the people but indigenous people are going to be more vulnerable as compare to other section of the community. This is due to the fact that indigenous people live more close to the natural environment and they are the first one to experience, identify and adapt to any climate related change. However, indigenous people make the use of their own wisdom and accumulated knowledge from their predecessor over time to adapt to any change in climate. They can perceive the change by disappearance of certain animal and plant species, change in direction of wind, mating behavior of animal and so on. These all criteria they established to identify climate change not just based on any assumption or perception of individual. They correlate the change with the certain phenomenon over a long period of time with scientific pursuit and validated it through their real life experience. These all wisdom, insight and knowledge of local people termed as indigenous technical knowledge.

More precisely, the agricultural practices followed by the farmers which are generated locally by themselves and inherited over a long period of time are referred to as indigenous knowledge[2]. These knowledge ranges from-cultivation practice to post harvest preservation and management, agro –forestry to bio-diversity conservation and management. This knowledge also include animal rearing, healthcare, fishery and fish preservation, water and farm equipment and homestead management[3]. One important feature of indigenous knowledge is that it is highly adaptable to the new problem and new situation. For example climate change is a recent problem to our society and civilisation. Many traditional societies in our country already developed their own indigenous knowledge base and formulated required strategies to adapt to climate change.

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However, integration of those indigenous technical knowledge and strategies with our formal adaptation strategies was neglected for a long time. As a consequence till today indigenous people are the most vulnerable section to climate change. Now it is time to recognize their wisdom, to take the advantage of already available knowledge and integrate that knowledge with our formal basic research. In this context, the present study aimed at documenting the different indigenous practices of Arid and Himalayan ecosystems in relation to climate change and existing livelihood, most of which were nurtured by the community and generally discovered by the elder members of the community but unevenly distributed in the community.

Methodology

The study was conducted in the Himachal Pradesh of the Himalayn ecosystem and in Rajasthan of Arid ecosystem. Two districts from Himachal Pradesh namely Shimla and Kullu were selected purposively keeping in mind the impacts of climate change. Theog and Nagar blocks representing apple belts from Shimla and Kullu were purposively selected. Thereafter, two villages-Sandhu and Koti from Theog block and another two villages–Katrain and Kamsari from Nagar block were selected purposively. Finally, 25 apple growers from each village were selected randomly. Similarly two districts namely Jodhpur and Jaisalmer were selected from Rajasthan purposively, which represented arid ecosystem. Luni block from Jodhpur and Jaisalmer block from Jaisalmer district were selected purposively. Four villages, namely Lonawaskhara, Porkkhawas, Bharamser and Pora were selected respectively from Luni and Jaisalmer blocks purposively followed by the random selection of 25 farmers from each village for our study. Thus a total of 200 farmers comprised the sample for the present study.

Documentation of ITK was done using both primary and secondary sources of information. In-depth study was designed by combining descriptive survey and anthropological approach of participatory study. Validation of ITKs was done through modified QuIK (Quantification of Indigenous knowledge) method by selected key persons who were experienced in particular ITK(s). Major documented indigenous knowledge as revealed by present study was as follows:

Himachal Pradesh

Climate

Movement of animals and insect

Farmers in Himachal Pradesh believed that if honeybee fly toward northern hill then there will be no rainfall and good rainfall is expected if it moves towards southern hill. Some section of the community believed that good rainfall occurred when winged termite emerged from the ground. Another section of community believed that when glow worms flew upwards, it indicated the onset of south west monsoon. The farmers of Himachal Pradesh reported increased temperature, change in rainfall and snowfall pattern under changing climatic conditions. They can take the necessary action for field preparation and procuring inputs based on aforesaid traditional forecasting methods to adapt to changing climatic pattern.

Farming system

Mind cultivation/ Bidd cultivation

Farmers of Himachal Pradesh developed several layers of plain land by cutting the slope of hill. Popularly it is known as terrace cultivation. Often such land is formed into multiple terraces, giving a stepped appearance. It conserves the soil as it slows rapid surface run-off which would erode the soil as it wipes off the top layer depositing it further down the hill. Lower terraces are not eroded by rapid surface run-off under heavy rainfall condition, and the highest terraces still get water. The terrace or mind cultivation was gaining high importance under changing climatic scenario due to its potential to conserve soil and water. Moreover, farmers also experienced heavy rainfall within few days which increase the potentiality of soil erosion and frequent landslide in sloppy hill. The farmers of Kenya, Uganda and Tanzania already adapted to climate change led soil erosion in the form of heavy snowfall, landslide and rainfall through *"Fanya Zuu Terraces* (terrace cultivation)" in more scientific way (40-50 cm high terraces and 10-20 m apart with suitable agro-forestry practices)[4]. Therefore, this century old traditional practices need to be relooked in context of climate change in more scientific and participatory way for better adaptation to climate change led soil erosion.

Disease management

Apple paste

The diseases like scale, canker, scab etc were occurring in high magnitude under changing climatic

condition in Himachal Pradesh. To solve the issue, farmers of Himachal Pradesh prepared an indigenous paste by mixing diesel oil or *alsi (linseed) oil, nelathota* (CuSO4), and *chuna* (Lime). They sprayed it on in the affected portion of the tree to prevent mainly scale disease of the apple plant (Fig. 1). Generally they applied this paste on the cut spot after pruning.

Application of ash

The farmers reported increased frequency of diseases like drying and yellowing of leaves of major vegetables; increased attack of red pumpkin, beetle; wolly aphid of apple and problems like low soil moisture and fertility of soil due to increased temperature and low snowfall. Few farmers applied wood ash in vegetables like onion, garlic, brinjal and tomato field to supply the nutrient and to control pests like red pumpkin beetle, aphid and thrips, etc (Fig. 2). The ash also helped to maintain the soil moisture level under hot and dry weather and ensured better production and income.

It is well known fact that Co_2 is the major contributor to global warming and consequent climate change. It was reported that the application of fly ash holds tremendous potential in Co_2 sequestration through mineral carbonation of ash in the soil[5]. The traditional practice of applying ash can help in adaptation by buffering soil *p*H, improving soil texture, improving nutrient status as it contain K, Ca, Mg, S and P. It also promotes higher plant growth and nutrient uptake[6,7]. Thus, application of ash helped to mitigate the climate change through CO_2 sequestration by mineral carbonation of ash in soil besides controlling insects of major vegetables.

Fig. 1—Layer of apple paste on branch of apple tree

Fig. 2—Application of ash on apple orchard

Crush of *Rambaan*

The farmers of Himachal Pradesh uses crush of '*Rambaan'* (*Agave americana*) with irrigation water to control pest in rice field like leaf folder, rice *hispa*, etc. as these were reported in high magnitude. Krishnaiah & Varma[8] also highlighted the increased problem of rice *hispa* in Himachal Pradesh under changing climatic condition under humid climate and wet season.

Rainwater harvesting

Chal

The most valuable natural resource in the Himalayan ecosystem is water. The conservation and management of water resource is very important for sustenance in hilly ecosystem under less rainfall condition. So, the farmers of the area build an indigenous method to collect and store the water known as '*chal'*. It is a small water storage structure on both sides of the hill. The water is used for drinking purpose of cattle and irrigation. The length of '*chal'* varies from 2-3 m and depth from 1-2 m. It is widely practiced and helped to reduce the vulnerability level of farmers under prolonged dry spell.

Food habit

Siddu

The mercury in Himachal Pradesh goes down to below 0^0C during winter. To protect from the extreme cold, people indigenously developed their dietary behavior to keep their body warm. '*Siddu'* is an example of such dietary innovation of Himachal Pradesh. '*Siddu'*, also called '*khobli'*, is an ethnic fermented wheat product. At first, the wheat flour is mixed with water and then '*malera'* (previously left dough of '*siddu'*) is added. Then it is left for fermentation for 4-5 hrs at room temperature. Then, it is stuffed with spices, paste of opium seeds, black gram and walnut, and is steamed before consuming.

Forage management

The farmers of Himachal Pradesh experienced irregular and erratic rainfall under changing climatic conditions. Moreover, heavy rainfall was reported within few days in monsoon season leading to spoilage of straw of rice, wheat or maize or other grasses due to penetration of water in the forage structure. To prevent spoilage, the farmers covered the top of triad shaped forage structure with low cost locally available polythine. This also helped them to protect the forage structure from damages due to hailstorms.

Rajasthan

Climate

Movement of animal and birds

A large section of the community told that appearance of many butterfly together indicates a good rainfall and bumper season. Some farmers reported that appearance of ants and termites indicates an imminent rainfall and good season. The findings of Pareek *et al.* (2011)[9] also supported this indigenous wisdom of local people about climate forecasting.

Symptoms of natural vegetation

The framers of Rajasthan observed that if the *khair* trees (*Acacia catechu*) become extra bushy then a dry spell is imminent. This traditional wisdom helped them to take necessary adaptive strategy.

Movement of stars and cloud

The farmers of Rajasthan believed that if cloud rises in the east then there will be good crops. Some farmers believed that the pale and yellow colour of moon is associated with good rainfall whereas red and white colour is indicative of rainless condition.

Thumb rule

Farmers of Rajasthan developed some thumb rule over a long year of experience. It was believed that good rainfall occurred after every five years. They also believed that the year with heavy storm (*aandhi*) was associated with good climate and well distributed rainfall.

Soil management and land preparation

Kanabandi

It is a traditional method of controlling wind erosion. It was reported that high temperature and low precipitation in the dry ecosystem leads to poor organic matter production, rapid oxidation and poor aggregation which ultimately raise the potentiality of wind erosion[10]. In order to break the speed of wind near the ground level, a micro wind-break of dead wood are built. The locally available vegetations are used to prepare the '*kanabandi'*. The vegetation is laid down in line across the wind direction in rows approximately 20-30 m apart and then soil is dumped on vegetation to keep them in place. Drought resistant grasses like '*dhaman'* (*Cenchrus sp*.) and '*Sevan' (Lasirus sindicus*) are sown on the leeward side of windbreak. High velocity winds are thus intercepted by '*kanabandi'* and the lifted soil particles accumulate near the '*kanabandi'*. It also traps small organic particles that fly with the harsh summer wind. These particles act as manure, improve moisture regime, and enhance productivity.

Jhoor

Soil in Rajasthan is highly saline and porous with low productivity. To enhance the soil fertility and productivity, farmers developed a traditional soil management system like *Jhoor* which involves cutting of local shrubs and grasses into very small pieces and spreading over farmland before cultivation. It improves soil quality and productivity, and thus ensured higher crop yields and income.

Soil salinity problem in arid region was mainly attributed to over irrigation of agricultural land. However, saline dust storm under changing climate may contribute to increased salinity problem of Rajasthan. Saline dust storm generally transports high concentration of fine grain saline and alkaline material like sodium sulphate, sodium chloride, etc. which stimulate soil salinization. These surface sediments have a loose texture due to salt accumulation, resulted in poor vegetation growth; so wind erosion occurs easily. Soil salinisation in arid region is mainly due to the upward transportation of dissolved salt with water and then leaving salt particle near ground due to evaporation of water[11]. This process may be accelerated under increased evaporation rate due to rising temperature. In this context, this traditional practice may restore soil fertility and reduce the soil salinity problem by increasing the organic matter of the soil through *Jhoor* practice.

Jhopa

It involves covering tree-saplings by local brushwood to protect against strong sun, winds, cold winters, which showed an increasing trend due to climate change besides the protection of grazing by free animals. This traditional practice helped to protect the crop from climatic hazards like *andhi*, strong wind storm and heat wave (*loo*).

Farming system

Khadin farming system

It is also known as *khudi* or oasis farming system used to harvest water. It is a traditional runoff farming system and is found where rocky catchment and valley plains occur in proximity. Water from large surrounding field area is collected to a natural common point. Here, first the natural slope of the land surface is assessed and then some natural collection point of water is identified at community level. The crops adapted to dry condition are grown in *khadin* system without any irrigation as the soil is fertile in *khadin* area and its retention capacity of residual soil moisture is high. The system is very effective even when annual rainfall is less than 200 mm. The water is collected and used for irrigation purpose in the off season. Jaisalmer is reported to have 500 such *khadin* over an area of 12140 hectare[12]. The water of *khadin* helped to recharge aquifer and ground water. This ITK is an effective option for efficient water resource management in the context of climate change induced scarcity of water.

Storage structure

Jupka

It is traditional fodder storage structure. It is made of *bajra* straw, leaves of *moong* (Green Gram), moth (*Vigna aconitifolia*) and *guar* (cluster bean, *Cyamopsis tetragonoloba*) plant (Fig. 3). The coverage by *bajra* straw prevents water seepage and thus spoilage of fodder. The structure helped to preserve the fodder from extreme heat wave, spoilage from rainfall and sand storm.

Kothi/* Tuke/*Kotha

This is an indigenous grain storage structure. The wall of *kothi* was made of a mixture of cow dung, soil and local grass (Fig. 4). But the base was made from cement to prevent the attack of termite, rat and other insects. The mixture of soil and cow dung helped to keep the temperature low inside the structure. The *kothi* is used to store the *bajra*, *moong* (Green gram) and *moth* (*Vigna aconitifolia*). The farmers were so rational and scientific in their aptitude that they put one small earthen vessel at the top of *kothi* to prevent seepage of water through the structure and thus prevented spoilage of grains.

Indigenous compost pit

Application of compost helped to restore the fertility and soil moisture. So, farmers indigenously developed some compost pit structure in which a natural earthen pit of 10′×5′×3′ was prepared wherein cow dung, grasses and wasted vegetables are dumped, and opening of pit is closed for 3 month. The application of compost fertilizer not only increases the fertility but also helps to reduce the incidence of termite attack. The farmers shared that if they applied raw cow dung then attack of termite increased but if they applied compost then attack of termite was less.

Water harvesting structure

Tanka

Water is a scarce natural resource in arid ecosystem. To address the issue, farmers have developed some indigenous method to collect and store the scarce water resource. One such example is *tanka* (Fig. 5) which is a tank of 20 ft depth and 18 ft width adjacent to house and used to collect water from roof and adjoining field. It is constructed in a circular or rectangular shape on a bare ground where surface runoff can be diverted to the *tanka*. It can store up to 92000 L of water. The water is used for drinking purpose and irrigating the field in off-season.

Fig. 3—*Jupka*

Fig. 4—Small sized *Kothi*

Human health

Anti-diabetic plant

Climate change brought several health related hazards in the area like heat stroke, vector borne diseases, body pain, diabetic, etc. The climate change has indirect relation with diabetic disease as blood glucose level is related with temperature. The farmers reported higher number of diabetic disease due to changing lifestyle coupled with change in temperature. To address the issue, *Cajanus cajan*, bud and flowers of *Hibiscus rosa-sinensis*, and buds and flower of *Pisum sativum* were used by the community as anti-diabetic diet.

Animal husbandry

Ola/ Chappar

It is an indigenously made cover or dress of animals made form *kheep* grass (*Leptadenia pyrotechnica*) to protect the animals from high temperature.

Disease

Dysentery

Three pieces of *Golmorich* (Black pepper), 2 teaspoon full ghee and 50 gm smashed *Jastimadhu* are mixed with 250 ml cold water is drenched to the animal.

Arthritis

The root of *Babul* (*Acacia arabica*) is mixed with mustard oil in the ratio of 1:3 and is drenched to the animal.

Fig. 5—*Tanka*

Validation of ITKs

Community level validation was done through modified QuIK method by the key informants of the study area. The farmers were asked to rank the each ITK based on their degree of use and relevance under changing climatic condition. Garret's ranking technique was employed as all the farmers did not rank all the items. Finally first 5 ITKs were selected from both the states. Validation was done through key informants based on their usefulness, cost effectiveness, availability, easiness and side effects in 5 point scale. The major findings of the study were as follows:

The study revealed that farmers ranked apple paste as the most useful ITK of the area followed by *mind* cultivation, movement of honeybee to forecast rainfall, application of wood ash and eating *siddu* in extreme cold condition in Himachal Pradesh. The total mean score of wood ash ($\bar{x}$ = 4.12) was more than movement of honeybee ($\bar{x}$ = 4) to forecast rain mainly due to its high applicability in farming. The farmers preference for the ITK was mainly based on the degree of problem they are facing in farming and contribution of ITK to solve the problem. For example, apple paste was ranked as the first preferred ITK because now farmers were experiencing severe problem of scale, apple scab, canker and wooly aphid under changing climatic condition. Application of apple paste helped the farmers to control the problem in more efficient and cost effective way (Table 1).

In Rajasthan, the KI ranked *khadin farming system* as the most popular ITK of the area followed by *tanka, jhoor and kothi and kanabandi*. *Khadin* farming system were highly valid indigenous practice to manage water stress ($\bar{x}$ = 4.18) in the area. Farmers' ranking in Rajasthan revealed that ranking was done mainly based on their immediate problem and contribution of ITK in solving the problem. Water is the major issue in Rajasthan, and *Khadin* farming system helped to store and recharge ground water facilitating off-season cultivation and additional income. Similarly *tanka* is another traditional practice

Table 1—Ranking of ITKs in Himachal Pradesh, n=10

ITKs	Use-fullnes ($\bar{x}$)	Cost effectiveness ($\bar{x}$)	Availability ($\bar{x}$)	Easiness ($\bar{x}$))	Side effects ($\bar{x}$)	Total Mean Score ($\bar{x}$)	Ranking
Apple paste	4.5	4.6	3.8	4.3	4.3	4.32	I
Mind cultivation	4.2	3.9	4.0	3.6	3.5	3.84	IV
Movement of honeybee	3.8	4.1	3.6	4.0	4.5	4.0.	III
Ash application	3.7	4.2	4.2	4.1	4.4	4.12	II
Siddu	4.0	3.7	3.9	3.6	4.2	3.88	V

Table 2—Ranking of ITKs in Rajasthan, n=10

ITK	Use-fullness ($\bar{x}$)	Cost effectiveness ($\bar{x}$)	Availability ($\bar{x}$)	Easiness ($\bar{x}$)	Side effects ($\bar{x}$)	Total Mean Score ($\bar{x}$)	Ranking
Kanabandi	4.0	3.8	3.9	3.4	4.4	3.90	V
Tanka	4.5	3.9	4.1	3.7	4.2	4.08	II
Khadin farming system	4.6	4.4	3.6	3.8	4.5	4.18	I
Jhoor	4.1	4.0	3.9	3.8	4.3	4.02	III
Kothi	4.2	3.7	3.9	4.2	4.5	4.10	IV

to harvest rain water for irrigating the field and ranked as second popular ITK (Table 2).

All these findings revealed that all the ITKs were highly useful for the local community to manage climate change induced stresses. So, it is an immediate need to scientifically validate the technology for their large scale diffusion in the community.

Conclusion

The present study disproves the myth that innovation should always be transferred from lab to land for betterment of human being. Some indigenous wisdom like forecasting of rainfall and drought through the movement behvaiour of termite, ant, butterfly, etc. was widely practiced by the community to starting their field preparation for farming. These, traditional forecasting techniques are highly relevant for their adaptation towards climate change. Different water harvesting structures like *tanka* and *chal* are widely used to capture the most scarce natural resource i.e. water for better adaptation under erratic rainfall condition in changing climate scenario. Traditional farming system like *Khadin* farming system is the sign of wisdom of local community and most relevant adaptation technique towards climate change available till now. But these technologies are restricted not only within a particular community but also unequally within that community. So, there is widespread variation in adoption of these technologies among the farming community. Therefore, the government has to play a major role in diffusing these technologies in the region by involving different extension agencies, NGOs, local agencies, civil and religious organizations, etc. Government should develop appropriate policy to validate these technologies followed by their promotion among the farming communities to ensure adoption of these technologies.

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