Indigenous knowledge and sustainable agricultural resources management under rainfed agro-ecosystem

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The paper demonstrates the tribal farmers’ wisdom, perception and their criteria developed for the agricultural resources conservation and survival under the risk prone agro-ecosystem of Dindori district of Madhya Pradesh. The investigation was carried out in seven villages dominated by Gond, Baiga and Pradhan tribes. Conventional and participatory methods were applied to record the data. The result indicates that, despite the increasing commercialization of agriculture, the great majority of the farmers in the area are peasants, or small-scale producers. After centuries of cultural and biological evolution, traditional farmers have developed and inherited complex farming systems, adapted to the risk prone situations. These have helped them to conserve and sustainably manage harsh environments and meet their subsistence need without depending on costly energy based inputs. Agro-ecological and ethno-ecological evidence in vogue among the tribal community increasingly indicates that these systems are productive, sustainable, ecologically sound, and tuned to the social, economic, and cultural features of the local tribe. Some of the cultural adaptations that farmers have developed in the area include: domestication and conservation of diversity of plants and maintenance of a wide genetic resource base. Farmers are competent to make vertical agricultural development through the series of traditional resource conserving practices, variety conservation, weed, pest, nutrient, and water management practices to deal with socio-environmental changes. Scientists involved in agricultural research and development must try to learn, systematize and incorporate the farmers' practices, before this wealth of practical knowledge is lost forever, given that most traditional farming systems are rapidly disappearing in the face of major social, economic and political changes occurring in developing societies.

Keywords: Indigenous knowledge, Natural resources conservation, Indigenous varieties, Tribal farmers, Sustainability

Resource conserving practices of local peoples drawn from their traditional knowledge systems have been described from many parts of the world and for many different cultures and environments1-7. Human societies across the world have developed rich experiential wisdom and explanations relating to the environments they live in and the past few decades have witnessed the importance of understanding the linkages between social and ecological systems for managing the use of natural resources7,8-12. From a social perspective, this renewed interest is partly due to a new-found pride in traditional values and institutions, and their value as a tool for conserving natural resources. By living in rich and variety of complex ecosystems, local people have developed an understanding of the properties of plants and animals, the functioning of ecosystem, food web and techniques for their optimum use and management. In developing countries, the rural communities relied on locally available species for many-sometimes all-foods, medicine, fuel, building materials and other products.

Today, the world's indigenous knowledge base is as much at risk as is the indigenous flora and fauna. The diversity of the world's indigenous knowledge, like its biological diversity, should be preserved. An important goal of this preservation should be to use indigenous knowledge to enhance the quality of life of those who have generated it. Agro-ecological and ethno-ecological evidence increasingly indicates that these systems are productive, sustainable, ecologically sound, and tuned to the social, economic, and cultural features of any farmers13,14. Cultural adaptations that farmers have developed in India include:

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domestication of a diversity of plants and maintenance of a wide genetic resource base, establishment of diverse production zones along altitudinal and vertical gradients, development of a series of traditional technologies and land-use practices to deal with altitude, slope, extreme climates, etc. and different levels and types of social control over production zones. Looking to the importance of role of indigenous knowledge in sustainable use and management of agriculture and natural resources, an attempt has been made to identify the tribal farmers’ wisdom regarding the local practices in vogue among community to manage and sustain the agriculture and natural resources.

**Methodology**

The investigation was conducted in the purposively selected Gond, Baiga and Pradhan tribal communities of Dindori Development Block of Dindori district, Madhya Pradesh, Central India. The study area comes under the North-Eastern hill zone of Chhattisgarh, which is attributed by the sub-tropical climate. The agriculture of the region is totally dependent on rains and about 97% of the total cultivated area comes under rainfed agro-ecosystem. The economic condition of the farmers is poor and they are not able to bear the cost of high inputs required for energy based agriculture. The social customs, food habits and family structures of farmers are also factors which are responsible for doing the indigenous farming system.

Looking to the nature of study, the qualitative approach, which is more appropriate in case of studying indigenous knowledge systems and natural resources, has been chosen for the explanation of qualitative data. Personal interviews and participatory methods were used complimentary to carry out the study. Both approaches have their place and their results can be complementary and possibly cross-validate each other. A pre-appraisal dialogue, using a group discussion method was undertaken. Group discussion was held in each of the selected villages of study area (Fig. 1). The size of group varied from 10 to 25 participants with an average of 15 participants. Open-ended questions on the history of the area, past and present management practices, types of resource use, historical and present distribution and abundance of resources were discussed and recorded to establish further detailed discussion points, which formed the basis for interview with key informants.

The research was undertaken in the purposively selected seven villages of Dindori Developmental Block of Dindori district, Madhya Pradesh. These villages were namely Sarahari, Ghanaghat, Kohka, Chhanta, Kanaisang, Dandbichhiya and Sivari. A representative group of 20 farmers from each village of various ages and resources have been selected for making focus group discussions towards necessary practices. An agro-ecosystem analysis was done and resource flow maps were developed by using the participatory rural appraisal (PRA) method for analyzing the present use of natural resources and its management practices in relation to agriculture at village level. The interview schedule was also used to analyze the farmer’s wisdom and different cases like perception regarding their indigenous varieties and HYVs. Data were collected with the aid of an interpreter over a period of six months, from October to March, 2004. Interviewees were chosen by means of the stratified convenience sampling of households of purposively selected villages. Interviews were semi-structured in format, and covered subjects pertaining to perception, crop rotations, cropping pattern, crop management practices, soil, water & fertility management practices, ways of conserving indigenous paddy varieties, perception towards introduced high yielding varieties, weed management and pest management. The data were analyzed and inferences have been drawn using the descriptive statistics like percentage, mean and rank.

**Results and discussion**

**Farmers’ knowledge of soil and soil fertility**

The soil of the locality has been broadly classified into two main categories on the basis of its use. They are agricultural and non-agricultural soils, used for farming and house making or other domestic purpose. Farmers have classified soil on account of topography, texture, colour, stickiness, depth and crops’ compatibility (Table 1). They perceive soil fertility in terms of crop yields, both qualitatively and quantitatively, which they obtain from the particular field. The soil, which gives higher crop yield is more fertile and vice versa. The fields, which are leveled and plain, are thought to be more fertile.

Farmers’ classified soils are positively correlated with the topographical position. The first class of soil fertility that is available in Kali Mitti is being ranked
first in terms of soil fertility among all the soils (Table 2). *Kali Mitti* has greater potential for the higher productivity, due to higher moisture retention capacity. This soil is found to be suitable for most of the prevalent cash crops like green gram and cauliflower. *Sehra* soil is second most fertile soil for crop production. Well-drained and moderately sloppy nature of *Sehra* soil allows farmers to cultivate *kodo, kutki, pea, linseed, red gram, green gram and black gram* successfully. Farmers assigned third rank to the *Bharra* and *Moothbarr* soil for its fertility level. They are light textured and slightly sloppy enabling farmers to grow mixed cropping of cereals and oilseeds to fulfill their needs. Whereas, *Bharra* and *Kochai* are ranked fourth and fifth, respectively due to their low soil moisture retention capacity and low response to fertilizers. On account of lower depth, uneven nature, high stones, low yield potential, high erosion and high risk of crop production, farmers have assigned the sixth ranks to the *Karkatiya Bharra* soil. *Kodo, kutki, green gram, black gram, amta* and *niger* crops are found to be more compatible for cultivation in this soil.

### Adaptation of resource conserving indigenous cropping system

The tribal farmers have made trial and error to select different crop rotations and combinations as per the compatibility of soil fertility and ecological diversity (Table 3). Beside, they also consider long-term needs of food, fodder and overall economic gain through making well-planned strategies of crop rotations based on the climate and locally available resources with them. Interestingly, the rationality of the farmers’ crop rotations was found to be scientific by the newly implemented project. To make popular,
again after the refinement in needed practices, these models have been diffused in the similar other areas also\textsuperscript{27}. Few models of farmers’ cropping system are discussed below:

1 \textbf{Red gram with rice}

In most of the cases, red gram crop is taken on the natural drains and fish ponds with an intention to provide the defense by its deep root system to control soil erosion. Apart from it, the \textit{Kali soil}, which is most fertile is found to be best suited for tall varieties of paddy under low land areas. The seed of red gram is sown on the bunds of paddy field. The reason behind sowing red gram on bunds is to make sure of getting additional income from the pulse crop. The network of roots of red gram facilitate in controlling the soil erosion during rainy season. The environmental sustainability of the red gram crop is assured by growing it in each year by every farmer. While, the economic sustainability of red gram sowing is assured by exchanging it with the flowers of \textit{Mahua} (\textit{Madhuca latifolia}, used for making varieties of ethnic foods and medicines) and black gram seeds\textsuperscript{13}. Generally, after harvesting and threshing, the seeds of red gram are graded in two classes i.e. superior and inferior on account of seed size. The superior seeds are either sold or used for exchange. Whereas, the inferior seeds of the red gram is used in the daily food system. This sustainable model has resulted as a source of hypothesis for the Regional Agriculture Station to design policy and implement the project. After three years of experimentation, the agronomist and soil scientists have succeeded in developing several other similar crop rotations on the basis of refinement\textsuperscript{28}.

2 \textbf{Utera cropping system}

Under the rainfed agro-ecosystem, the local sense of ‘utra cropping’ is “sowing of the next crop seeds before harvesting the primary crop for efficiently utilizing the present status of moisture”. \textit{Utera} cropping is only adopted in \textit{Kharif} season. This system help farmers to use the available moisture under dry land areas and diversify the cropping system by using two or three pulse and cereals crops to reduce the risk and get food for their survival. For successful \textit{utra} cropping system, seeds of the local pea, linseed, local variety of black gram and \textit{Lathyrus} (khesari) are grown. The \textit{utra} cropping is only followed in the field of the paddy crop, because most of the paddy cropping area is in the microenvironment level by conserving the water from the natural resources. Before 15 days of harvesting the paddy crop, the seeds of above mentioned crops are broadcasted. The environmental and economic sustainability of the \textit{utra} cropping system is assured by compatible ecological conditions and harvesting more than one crop, without applying the additional external inputs. Looking to the popularity and sustainability of this system, ICAR has implemented a NATP project in 1999. Results indicate that after harvesting 20 q/ha paddy crop, about 16-18 q/ha yield

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
Types of soil & Average fertility level scoring \* & Fertility rank \\
\hline
\textit{Kali} & 8.5 & I \\
\textit{Bahra} & 7.0 & III \\
\textit{Bharra} & 6.5 & IV \\
\textit{Moothbharra} & 7.0 & III \\
\textit{Karkariya bharra} & 4.5 & VI \\
\textit{Kochai} & 5.0 & V \\
\textit{Sehra} & 8.0 & II \\
\hline
\end{tabular}
\caption{Ranking of soil fertility by the farmers}
\end{table}

\* The fertility score was decided based on the average of 10.0 continuum scale in the focus group discussions organized with farmers in different villages

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
Soil types & Crop rotations \\
\hline
\textit{Kali} & Paddy-gram, paddy-lentil, paddy-fallow, paddy-pea, paddy-local wheat \\
\textit{Bahra} & Paddy-pea, paddy-gram, paddy-\textit{lathyrus}, paddy-wheat, paddy-somewhat vegetable. \\
\textit{Bharra} & Maize-fallow, maize+\textit{amta}-fallow, \textit{kodo}+\textit{amta}-fallow, \textit{kodo}+red gram-fallow, \textit{niger}-fallow, \textit{kutki}+ red gram-fallow, \textit{kutki}-fallow. \\
\textit{Karkariya Bharra} & \textit{Kodo}+\textit{amta}-fallow, \textit{kodo}+red gram-fallow, \textit{niger}-fallow, \textit{kutki}+ red gram-fallow, \textit{kutki}-fallow, \\
\textit{Kochai} & Paddy-pea, paddy-fallow, paddy-vegetable. \\
\textit{Sehra} & Paddy-pea, paddy-gram, paddy-lentil, paddy-wheat. \\
\hline
\end{tabular}
\caption{Different crop rotations prevalent under varying types of soils}
\end{table}
of local pea and 14-16 q/ha *Lathyrus* (lentil) could be harvested under the farmers’ demonstration fields.\(^1\)

3 **Badi cropping system**

Tribal people are habituated to grow the multifarious diversified crops in their local surroundings of the home and kitchen gardens also. The basic purpose for the adaptation of the *Badi* cropping system is to ensure the variety of cereal foods, vegetable and fruits by utilizing the fertile land of home surrounding areas. This system is prevalent in both seasons i.e. *Rabi* and *Kharif*. In the *Kharif* season, maize is grown in the line-sowing using the local implement called *Chadi*. In addition to this, various vegetables like *Lal Bhajee* (*Amaranthus tricolor* L.), ladyfinger, cucurbits, elephant foot yam and fruit crops are grown. Similarly local variety of *palak*, brinjal, tomato and chillies are grown in the small plots by adopting line sowing.

While, fruit crops like papaya, guava, *Zizyphus* and banana are planted around the bunds as living fence. In the *Rabi* season, *Rai* (mustard) is most popular for using its leaves as vegetable and seeds for oil. With the crop of mustard, seeds of the radish are broadcasted. Local varieties of vegetable crops like cucurbits, *palak*, *suran* (*Amorphophallus complanulatus*), gram and tomato are planted in small plots. Most of the varieties involved in the *Badi* cropping model, are indigenous and drought tolerant.

In addition to this, most of the tribal villages are located near to natural water resources from where they can use the water for irrigation through the traditional irrigation implements. The domestic wastewater is directed in the *Badi* cropping system, which facilitates for irrigation of the vegetable crops. The environmental and economic sustainability of the *Badi* cropping system is assured by availability of indigenous varieties of local food crops and the compatibility with culture, socio-economic and biophysical conditions.

**Creating micro-environment**

Dryland farmers prefer to create favourable micro-environments for diversification of their crops. They are skilled to make artificial *Khanti* (trench) and also use natural *Khanti* for growing the late variety of paddy in *Kharif* season. This *khanti* is most often used for growing the late variety of improved rainfed wheat in the *Rabi* season. The continuous wetness in *Khanti* in rainy season resulting from seepage of water from hilly areas and upper stream of soil helps in crop growth. The soil of *Khanti* is fertile due to addition of litters and organic matter from forest’s hilltops by rainwater. Some farmers make terrace for cultivation of rainfed paddy. In *Rabi* season just after harvesting the paddy crop, early variety of rainfed wheat and pea are preferred for growing under the created micro-environment. The productivity of these two crops is found to be more than in the normal field.

**Soil and water management**

In lowland areas, summer ploughing is most popular practice. Firstly, it enables the farmers to control insect pests and diseases by exposing the egg masses of insects and dormant spores of several pathogenic organisms to hot sun, so as to kill them and ensure sterilized soil condition for the ensuring crop in *Kharif*. It kills the embryos of weed seeds, which otherwise pose a serious threat to crop production in *Kharif* season. Thirdly, the practice enhances the water-holding capacity of soil by virtue of keeping it in fine tilth, which results in greater absorption of rainwater by decreasing runoff losses. Earlier study also justified that this technique helps in improving the moisture level in soil and increases the possibilities to improve the productivity of rainfed crop.\(^1\)

**Soil & water conservation and fertility management**

Some of the popular indigenous practices are discussed below:

**Making entire field into smaller plots**

This practice conserves the soil moisture by utilizing maximum irrigation water efficiently. Fields are made into smaller plots due to undulated land. By this way they control erosion of fertile surface soil as well as aids in water conservation.

**Mulching**

Mulching of some seedlings and crops is done to avoid the wind erosion and management of micro-climate in the nursery beds. The mulching material used is paddy straw, maize leaves or dry grasses.

**Making small earthier bunds/rock/wooden poles**

By using the materials like earth, rocks, wooden poles, the land is made into plots of convenient size for doing intercultural operations. Small branches of trees and leaves of plants are decomposed in the farmyard pits and then incorporated in the soil to
increase the fertility level and increasing the plasticity of soil which ultimately controls the soil erosion. It also helps in rainwater conservation.

**Burning of the leaves and branches**
Farmers often burn residues of crops and weed species to improve the physical properties of the soil, which controls soil dispersion from the rain drops and increases the soil fertility.

**Growing of grass along the border**
Planting of shrubs and perennial grasses like Sarpat (Sachcharum sp.) along the border decreases runoff considerably and reduces soil erosion.

**Retaining of tree stumps and roots**
Limited farmers leave the stumps and roots of smaller shrubs *in-situ*, which helps to bind the soil as well as maintain the fertility cycle.

**Ploughing and sowing across the slope**
In sloppy lands, farmers adopt ploughing and sowing across the slope to reduce soil erosion. Contour ploughing reduces slope erosion and loss of soil fertility.

**Sheep or livestock panning and fallowing**
Few farmers adopt the system of sheep or goat panning during end of winter season in the fallow land to fertilize the fields for next crop to be planted. Sheep and goats are panned in the fields for over 3-4 days. Farmers believe that, urine and excreta of goats and sheep are sources of good minerals and improve the soil fertility significantly.

**Incorporation of organic residues**
Farmers collect the leaves and branches of shrub and other weed species from the forest and crop field during summer season and spread it over entire field. These leaves and branches are set on fire before the onset of monsoon, thus adding the ash in soil. The water holding capacity and the smoothness of soil are improved in addition to improvement in the fertility level. Since women are major role player in the agricultural operations in every developing farmer’s communities, it was felt necessary to sought out their percentage of response in using the local practices of managing agriculture and associated natural resources. The result indicates that, the use percentage of these indigenous practices varies according gender. A mix type of response indicates that women were higher in using the practice of making entire field into smaller plots, burning of the leaves and branches, retaining of tree stumps and roots and incorporation of organic residues (Fig. 2). While, men were found to be comparatively slightly high or equal to women in following the practices of using mulch, making small earthier bunds by rock/wooden poles, burning of the leaves and branches and growing of grass along the border. It indicates that both male and female gender were at par in managing the indigenous agriculture and natural resources.

**Resources conserving weed management practices**
In the rice fields, farmers regulate the irrigation for suppressing weed growth. Before transplanting, the field is irrigated which allows the weeds to grow. Then the field is ploughed four to five times to control weeds. After transplanting of crops under low land areas, the regular flooding in the rice crop suppresses the weed growth. After transplanting, farmers do manual weeding and leave the weeds in the field. They take care that irrigation water should not go out in all sides of the plot. By this way the weeds decompose in the field itself. The mixed cropping and crop rotation with different crops and various combinations help in controlling weeds. Immediately after pre-monsoon showers, farmers clean the fields of palana (fallow) and kiyari lands and broadcast the seeds of rice and minor millets like *kodo*, *kutki*, fox millets, etc. at close spacing to suppress the weed growth.

**Resource conserving indigenous seed and cropping technologies**
Farmers use high seed rate to maintain optimum plant population and close planting to utilize rainy water to maximum extent and to reduce moisture losses. Early-planting is done as a crop protection advantage. Okra is planted early to escape aphid attack, which becomes serious towards the end of rainy season. Farmers prefer September sowing than in February, not only because of the reliability of rains, but because the season does not end up with low temperatures and high humidity, which favour development of insect and pests. It also provides some insurance against unpredictable rains, assuring that at least some plants will grow. In addition to the early planting strategy, early harvest may in some cases provide a crop protection advantage to the traditional farmer.
Farmers keep grains in one bamboo basket and submerge it in water. The basket is left for 4 days after taking out from water. The germinated seeds are broadcasted in the nursery for getting quick germination and growth. To maintain moisture, the basket is covered with wet gunny bag. This method also protects losses from grain eating birds immediately after broadcasting in the nursery. Nursery prepared by this way will give 2-3 weeks earlier crop than the dry seed broadcasted in nursery.

### Adaptation of location specific indigenous varieties

There is a high level of diversity in paddy, which is grown and conserved under varying micro-farming situations (MFSs, Table 4) in the study area. There are different micro-farming situations in which tribal community practices their diversities of location specific paddy varieties (Figs. 3-5). On the basis of soil colour, depth, topography, crop, irrigation sources and overall problems, farmers have classified three different micro-farming situations for the paddy crop in the study area (Table 4). With reference to these three micro-farming situations, various location specific indigenous paddy varieties were found, which are being conserved and cultivated (Table 5). These varieties are found to be compatible with the existing rainfed agro-ecosystems and local needs of farmers. Since majority of the farmers are poor and cannot afford the improved rice varieties, therefore they totally depend on these indigenous rice varieties even though low yielding.
Perception of tribal farmers regarding the attributes responsible for appropriateness of indigenous paddy varieties

The empirical data taken from 80 randomly selected tribal farmers revealed that majority (93.75%) of tribal farmers reported that location specific nature of the variety is responsible for its first rank (Table 6). Tolerance against the insect infestations has been attributed for giving second rank. While, resistance against disease, tolerance against moisture stress, compatibility of varieties with socio-economic conditions, yield stability, good taste, early maturity nature, unfailureness nature, low cultivation cost, faith in quality of seed, good fodder yield, good fodder quality and keeping quality are attributes in order of importance, which are responsible for the appropriateness of these varieties.

The documented varieties are grown as per the local resources and location specific strategies. For the upper stream like MFS-2 and 3 short duration varieties are selected and grown by the indigenous plough or by following the broadcasting method. While in the MFS-1 most of the varieties are planted in lines after using nursery prepared plants. For nutrient management, farmers depend on the farmyard manure and organic residues and do not adopt the chemical fertilizers. On account of the resistance against the most of diseases and insects, the tribal people do not follow any agrochemical. All these location specific paddy varieties are conserved and multiplied by the tribal people every year according to their needs. The above mentioned varieties are means for the tribal people to get successful production and environmental sustainability. The economic sustainability of all varieties is assured by its multipurpose use like foods, fodder, beer and other by-products.

Strategy for the conservation of indigenous varieties

The farmers have developed a set of strategies to select the seeds, maintain a seed stock and anticipate climate changes. These strategies, which are holistic in nature and include both physical and spiritual indicators, are widely practiced and are of significant relevance to agricultural management for the tribal people. It is argued that these strategies are important and that they are part of local culture. It is also known that the selection process and the choice of varieties differ from farmer to farmer. Farmers have succeeded in conserving by mass selection 2 or 3 different varieties of every major crop (in rice still there are 16 local varieties in spite of introduction of HYVs). One of the main differences between local and high yielding varieties is duration of maturity. Late varieties have potentially higher yields and are resistant to insect pests. Tribal people have no proper communication facility for getting real information about the weather. Besides, most of them have little exposure to the outside world. For predicting the rainfall and weather conditions and making the plan of seed sowing and crop management, the tribal farmers follow at least 16 indicators (Table 7).

Farmers, especially women, have developed their own ways of coping with climatic problems, combining different varieties on the basis of forecasts for the next rainy season. These forecasts are done by elderly men (often wisemen) and are based not only on physical indicators, such as ants, insects, bulbous plant, certain bird species or fruit setting in mango trees, but also on spiritual indicators. The wisemen use astrology (the positions of the moon and the stars) and biological indicators (Table 7) to make decisions on which crop mixture to plant. Many of these biological indicators are given due recognition in the society and a puja called Jagana Puja is done to worship these indicators. It is celebrated by every tribal for assuring the environmental sustainability of the indicators. In a year when rain forecasts are good,

<table>
<thead>
<tr>
<th>Attributes for appropriateness of indigenous paddy varieties</th>
<th>Percentage</th>
<th>Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early maturity nature</td>
<td>66.3</td>
<td>VIII</td>
</tr>
<tr>
<td>Low cost of cultivation</td>
<td>62.5</td>
<td>IX</td>
</tr>
<tr>
<td>Tolerance against insect infestation</td>
<td>87.5</td>
<td>II</td>
</tr>
<tr>
<td>Resistance against disease</td>
<td>86.3</td>
<td>III</td>
</tr>
<tr>
<td>Tolerance against moisture stress</td>
<td>81.5</td>
<td>IV</td>
</tr>
<tr>
<td>Higher food value</td>
<td>86.3</td>
<td>III</td>
</tr>
<tr>
<td>Good taste</td>
<td>68.2</td>
<td>VII</td>
</tr>
<tr>
<td>Good fodder yield</td>
<td>60.5</td>
<td>XI</td>
</tr>
<tr>
<td>Good fodder quality</td>
<td>57.6</td>
<td>XII</td>
</tr>
<tr>
<td>Tolerance to excess water</td>
<td>81.5</td>
<td>IV</td>
</tr>
<tr>
<td>Location specific suitability</td>
<td>93.8</td>
<td>I</td>
</tr>
<tr>
<td>Yield stability</td>
<td>70.5</td>
<td>VI</td>
</tr>
<tr>
<td>Keeping quality</td>
<td>55.5</td>
<td>XIII</td>
</tr>
<tr>
<td>Compatibility with socio-economic conditions</td>
<td>72.5</td>
<td>V</td>
</tr>
<tr>
<td>Faith in quality of seeds</td>
<td>61.3</td>
<td>X</td>
</tr>
</tbody>
</table>
women tend to sow more rice seeds and local maize varieties that are of short to medium duration. In dry years they sow more drought tolerant plants, such as stalked foxtail millet, kodo, kutki, and sorghum varieties. If the wisemen forecast drought or any natural calamities, then women select more seeds of varieties of different millets, pulse and paddy crops having shorter duration and early maturity.

Farmers’ perception regarding the introduced high yielding varieties

Very less percentage of the tribal farmers have adapted the improved varieties initiated by the State Department of Agriculture and ICAR. After the assumed success of Green Revolution in India under the irrigated farming situations, the government has initiated the intervention of crops’ varieties programme under the rainfed agro-ecosystem. Rural planners and policy makers were fighting to boost up the staple food production and to help the farmers to become self-reliant under vicarious rainfed crops as well as the rice crop. But results obtained from the study areas depicts that the introduced varieties of different crops do not reach the desired target due to its incompatibility with the micro-farming situations.

Farmers’ perception shows that they prefer varieties having to the characters of energy, their compatibility under varying micro-ecosystems, taste, cultural compatibility, productivity, and requiring little management efforts. The attributes of new varieties like high requirement of nutrients, plant protection measures, irrigation and intercultural operations are incompatible to the farmers’ overall socio-environmental conditions. These attributes influence the farmers whether they will conserve local varieties or adapt to new variety of rice crop. Basically, the selection process of seeds consists of saving the certain quantity of seeds, which is protected against the insect pests by applying different indigenous materials. It is clear from these discussions that, tribal farmers are well skilled in

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Characters by which prediction is made</th>
<th>Rainfall status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bindari Madhla plant</td>
<td>Flowering occurs thrice a year, first in the last week of April, second after the 15-20 days and third 25 days thereafter. The last flowering is the indicator for the rainfall</td>
<td>Average rainfall</td>
</tr>
<tr>
<td>Batar Kida</td>
<td>First flying of this insect in the herd i.e. during last week of May.</td>
<td>More than average rainfall</td>
</tr>
<tr>
<td>Fruits of Jamun</td>
<td>Deep blackish colour of the jamun fruits</td>
<td>Good rainfall</td>
</tr>
<tr>
<td>Fruits of the mango</td>
<td>Maturity of the fruits of local mango variety in the second week of the May to June</td>
<td>Average rainfall</td>
</tr>
<tr>
<td>Titihari bird</td>
<td>When this bird lays more than 3 eggs in last week of June</td>
<td>More than the average</td>
</tr>
<tr>
<td>Kenkda (crab)</td>
<td>If Kenkda is crying frequently in the night</td>
<td>More than average rainfall</td>
</tr>
<tr>
<td>Girgitan</td>
<td>If the colour of this reptile’s neck is red</td>
<td>Quick and good rainfall</td>
</tr>
<tr>
<td>Raza Ki Ghodi</td>
<td>If this insect is seen in the last week of June</td>
<td>Good rains</td>
</tr>
<tr>
<td>Raja Ka Hathii</td>
<td>Insect with the red body and fine hairs habitat in the light soil. If it walks fast in the June</td>
<td>More than average rainfall</td>
</tr>
<tr>
<td>Galaiya</td>
<td>If young one of this bird makes sound in the nest</td>
<td>Quick and average rainfall</td>
</tr>
<tr>
<td>Ants</td>
<td>If ants are walking fast holding their eggs in the mouth.</td>
<td>Quick and average rainfall</td>
</tr>
<tr>
<td>Bubbles of the rain drops</td>
<td>During the rainy season if the rain-drops are making big bubbles.</td>
<td>Heavy rainfall</td>
</tr>
<tr>
<td>Bahmaniya birds</td>
<td>If this bird is bathing with the soil dust in the last week of May or the first week of June.</td>
<td>Quick and good rainfall</td>
</tr>
<tr>
<td>Jangali piyaj</td>
<td>When this wild bulb produces pink white flower</td>
<td>Good rainfall</td>
</tr>
</tbody>
</table>

Table 7—Indicators used for rainfall prediction
selecting the location specific varieties suited to their socio-economic, cultural and environmental conditions. Few farmers have increased their production by trying to blend the modern agricultural practices with their local practices.

**Resources conserving pest management practices**

Various strategies such as stone throwing, use of traps or rat guards for rodents, hand picking of insect pests and hand hoeing is popular for pest management. About 90% of the farmers in this area practice handpicking and they use their indigenous varieties, which are mostly resistant or tolerant to insects and disease. Adoption of high seed rates in sorghum and thinning of shoot fly infested seedlings as well as hand removal of dead hearts and shoot fly larvae in improved varieties are quite popular practices done by the tribal farmers under the susceptible environment. The mechanical destruction of susceptible larvae by burying or exposing them during tillage was found to be common.

Since farmers live in the harsh ecosystem and do not have the cost bearing capacity, hence under few circumstances, farmers follow typical methods of pest control in different field crops. Though, most of the indigenous paddy and other crops’ varieties and tolerant to insects, certain indigenous practices are followed to avoid insect attack. Adult insects/caterpillars of different vegetables and pulse crops are physically picked from the plants of the infected field and destroyed by burning. The resulting ash is broadcasted to control the pest. The farmers believe that by this way they can reduce the insect damage. In the cultural practices, early sowing of sorghum and maize (with pre-monsoon rain) are carried out to escape the attack of shoot fly and other insect pests attack. Few nursery growing farmers of this area follow the practice of raising few castor plants (*Ricinus communis*) on their boundary of chilly fields as trap crop against thrips and jassids, which otherwise cause heavy damage to the chilly crop. It is also a common practice in this area to grow castor as a border crop in tobacco fields to keep *Spodoptera litura* under check since the pest prefers castor leaves.

During the month of May and June, farmers start collecting and spreading the leaves of *Beshram* (*Ipomoea carnea*) (Fig. 6) in the paddy field before ploughing. These leaves are left for over 8-10 days, set on fire and ploughing is done to mix the ash in soil. This practice is performed to control the termite problems in the rainfed paddy crop. Hence, farmers’ approach of managing insects pests and conserving indigenous biodiversity by using local practices are based on their knowledge of ethnoecology and are seems to be sustainable in nature as reported earlier.  

**Indigenous agriculture and natural resources conserving technologies**

It could be observed that the people learn about local practices of managing the indigenous agriculture and natural resources from various localized sources, where parents, nature, friends, neighbour, and village agriculture wisemen act as source of knowledge provider (Fig. 7). The rural schools and social institutions play significant role for the male gender, where they are dominant as member, while women were found to be comparatively more opportunist to learn the knowledge about indigenous agriculture and natural resources management from their relatives. So, the local sources of learning about indigenous knowledge play a crucial role to transfer the knowledge among community members from one generation to another for its use.

**Conclusion and policy implications**

The tribal farmers have some excellent informal wisdom based on trial and error for doing the sustainable farming under risk prone agro-ecosystem. Results indicate that sustainability concept as is ought to be applied to irrigated agriculture, is not applicable to rainfed agro-ecosystem. Sustainable agriculture and agro-biodiversity, therefore, require the use of energy and inputs to be subservient of the maintenance of environmental balance and at the same time fit into stable economic, social, ecological and cultural conditions of the farming community. Farmers are
trying to make the diversification by looking to cash-generating activities like domestication of ethnic vegetables and selling it in the market.

Indigenous agriculture knowledge lies with own tribal farmers, who are not only the practitioners and living authorities of local practices of soil, crops, micro-ecosystem management, ethnic plants and pest management, but also are repositories of indigenous wisdom. So, the generation of sustainable agricultural technologies for risk prone agro-ecosystem is possible by grafting the scion of Scientists’ wisdom on rootstock of farmers’ wisdom. The study depicts that unless we ground ourselves on the farmers’ wisdom towards farming system, which they already have, we will not be able to bring about major changes in development of risk prone agriculture so as to provide it with a sustainable base. On account of these conclusions, the following policy implications may be considered for promoting more sustainable agriculture under risk-prone agro-ecosystem:

1. Plan and manage rural landscape on the concept of location specific ecology and farming system to sustain the biodiversity and rainfed agro-ecosystem. Wherever appropriate, maintain wind
breaks, leave tracts of land in native habitat, use diversified cropping system, encourage pastoral activities, mixed species of forestry, adapt medicinal and ethnic fruits cultivation.

2. Optimize the use of local internal resources to the landscape whilst closing nutrients cycles by integration of productive system with local culture, needs and markets.

3. Promote and reward management that is consultation to indigenous farming system rather than hierarchical and efficiency led system.

4. The demand of indigenous-knowledge needs participatory research on natural resources management and requires the establishment of interdisciplinary team.

5. Expand knowledge on the complexity of indigenous agriculture system and agrobiodiversity and increase rational use of local knowledge for sustainable natural resources management and livelihood.

6. Promotion of micro-specific local management of land and agrobiodiversity with the active support of people’s participation in planning, management and evaluation of agriculture projects would facilitate and sustain the agro-ecosystems.

7. Educating the policy makers and planners about the value of local and indigenous knowledge systems in sustaining agricultural and natural resources can activate the integration of systems in the development process.

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