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Study of crop diversity and seed system in tribal Northern Hilly region of Chhattisgarh

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Abstract
A biodiversity portfolio approach to buffer against unpredictable environmental change in the Northern hills of Chhattisgarh state. Four cell analysis were used to assess the amount and distribution of crop diversity within farming communities. High number of native varieties were found under the class of fewer households in small area and some varieties were found endangered due to lacking farmers' choice. Diversity indices were used to analyse richness and evenness at the target site. Sonhat site (0.677) found more diverse than batauli Simpson's index (0.383). There are some defects in native varieties as very late maturity (>150 days), tall stature (> 140cm) prone to lodging and low yielder. Some unique native varieties still cultivating due to its medicinal property like Karhani (having high iron >20ppm and zinc content >32ppm) variety was used by many farmers to cure Anaemia and many other problems as therapeutic use as per their traditional knowledge. Jeeraphool Rice was found most prevalent, ceremonial and excellent eating quality scented rice of the Surguja as well as in Korea district. It is famous for its aromatic flavour, flakiness and taste.

Keywords: crop diversity, PGR, seed system, socio-economics, Surguja

Introduction

Chhattisgarh is a tribal dominating state of India that is endowed with rich and diversity of crop and forest genetic resources as 44.21% of the total geographical area of the state is under forest (India state of forest report 2009). The State has geographically situated between 17^0 47' to 24^0 6' North Latitude and 80^0 15' E to 84^0 24' East Longitude. Chhattisgarh "the herbal state" has 59772 km^2 area of forest comprising rich and unique biological diversity of several plants, which account for 44% of the total geographical area of the state and 8.4 of the country's forest cover (Shrivastava, A.K. *et al*. 2017) [37]. Chhattisgarh houses variety of food production systems and resources that includes wide range of varieties of rice, millets, pulses, oilseeds, fruits, edible flowers, tubers mushrooms and other forest gathered foods (Marothia, 2003) [26]. Traditionally, Chhattisgarh is known as the rice bowl of India having highest number of indigenous varieties that are adapted to various micro ecological conditions. Historically, many rice varieties have several therapeutic uses and are being used by tribal people (Tigga, R. *et al*. 2018) [42]. To harness the benefits of traditional agro-biodiversity UN Environment implemented Global Environment Facility (GEF) project named "Mainstreaming agricultural biodiversity conservation and utilization in the agricultural sector to ensure ecosystem services and reduce vulnerability" was initiated in Surguja and Korea districts located in the Northern hill zone of the state by the Alliance Bioversity International and CIAT, ICAR-National Bureau of Plant Genetic Resources (NBPGR) and Indira Gandhi Krishi Vishwavidyalaya (IGKV) Raipur, Chhattisgarh.

Crop improvement has played a pivotal role in sustaining and strengthening food, nutrition, health and livelihood security in the world from the earliest days of domestication (Nyadanu *et al*. 2014) [29]. Despite the enormous progress made in enhancing crop productivity through breeding, more than 800 million people (mostly children), are still under-nourished (FAO 2012a, b; Black *et al*. 2003) [12, 7]. In-situ and on-farm conservation of crops and their wild relatives is an important strategy for plant genetic resources conservation. A large number of wild plant species growing in farming environments is consumed or otherwise used by local people worldwide (Shacleton *et al*. 1998; High and Shackleton 2000; Ogle *et al*. 2003; Price 2006; Dansi *et al*. 2008; Msuya *et al*. 2008; Price and Ogle 2008; Achigan-Dako *et al*. 2010) [2, 16, 30, 32, 9, 28, 33, 1]. India has a rich and wide range of genetic wealth of rice. It has been estimated from various surveys that nearly 50,000 of rice is still being grown in the country (Patra, 2000) [31]. With the introduction of high yielding varieties and new technologies become a great threat to the security of the age-old practice of growing traditional varieties and landraces which may have immense potential for different important traits.

The GEF project focused on supporting the use of the rich and unique intra-specific diversity of crops that are of global importance to agricultural environments, to buffer against the increasing unpredictability in the amount and occurrence of rainfall, temperature extremes and the frequency and severity of pest and pathogen occurrence.

The objective of this project is to mainstream the conservation and use of agricultural biodiversity for resilience in agriculture and sustainable production to

improve livelihoods and access and benefit-sharing capacity of farmer communities.

The crops that are being dealt under the project include rice (*Oryza sativa* L.), black Gram (*Vigna mungo* L.), pigeon pea (*Cajanus cajan* L.), Kodo millet (*Paspalum scrobiculatum* L.), little millet (*Panicum sumatrence* L.), grain amaranth (*Amaranthus caudatus*), buckwheat (*Fagopyrum esculentum* and F. *tataricum*), mustard (*Brassica sps*. L.) and chickpea (*Cicer aeritinum* L.) This is being done through several tested community-based participatory approaches that support the maintenance of existing crop diversity and the introduction and deployment of appropriate new materials of target crops.

The various approaches include awareness campaigns, seed fairs, diversity fairs, strengthening seed supply systems and The establishment of community gene banks and other adaptive technologies that enable farmers to adopt and benefit from diversity rich solutions. The project works directly with farmers and communities to mainstream crop diversity on-farm to address the challenges they are facing due to change in the climate. This includes participatory evaluation and identification of suitable crop diversity and improved awareness and information on varietal adaptation based on scientifically sound evidence and its validation by farmers and communities, including men's and women's self-help groups. Income and other livelihood improvement actions through value addition and unique product development from local crops and landraces and their commercialization through an effective market link to support mainstreaming.

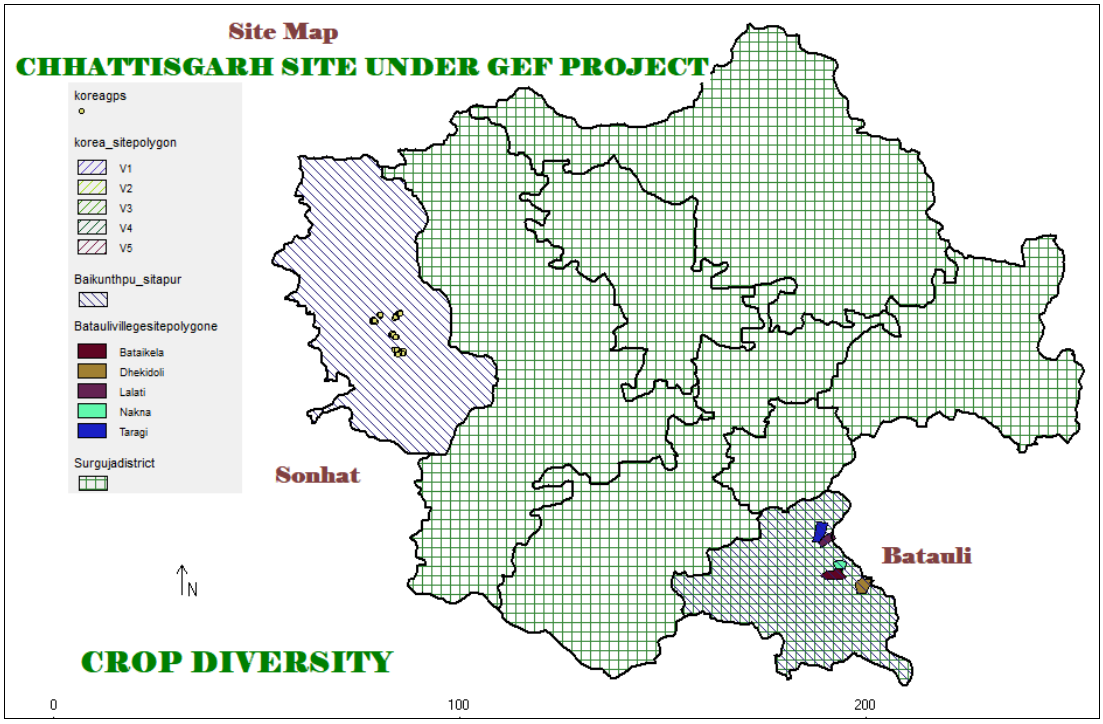

Fig 1: Site map of the target area under the project (*Source: DIVA GIS 7.5.0*)

Materials and Methods

The household survey was conducted from 1st November 2018 to 10 February 2019. Multiple social research tools and techniques were used to collect baseline information on the project sites (Fig.1). Secondary information was collected from related publications, reports, articles and census data 2011. Focus Group Discussions (FGD) were conducted after base line survey.

The baseline survey has been conducted with twin purpose (i) to improve understanding of current conditions, problems and opportunities to guide project interventions and (ii) to be able to measure change caused by project activities as part of the impact assessment.

The project and baseline survey focus on five topics of interest:

1. Seed system and crop diversity of target crops.
2. Farm livelihoods, income and market linkages.
3. Household consumption and nutrition.
4. Resilience to climate change impacts and related eco-system services.
5. Awareness about policy frameworks related to crop diversity.

Impact indicators

Four different impact pathways have been identified that will showcase how activities result as follows:

a. On-farm conservation and improved seed system of target crops.
b. Improved nutrition and consumption of target crop diversity.
c. Improved income from target crops.
d. Enhanced ecosystem services and resilience (vulnerability) to climate change impacts.

Community Focus Group Discussion

FGD tools were adopted to gather a preliminary understanding of the local context of the selected site. Group discussions were carried out to collect information regarding the local cropping system, crop diversity, seed management practice and processing equipment. A predefined checklist was used to gather the required information regarding seed management practices and processing techniques of mandate crops. Participants were invited randomly with an inclusive invitation that tried to be inclusive by gender ethnicity and castes as far as possible.

Four Cell Analysis (FCA)

The Four cell analysis is a rapid assessment technique to assess the amount and distribution of crop diversity within farming communities. It takes into account the richness and evenness aspects of inter or intraspecific diversity. This participatory tool was used to map out fruit tree diversity in the home gardens and orchards but can be applied also on annual crops. It is a method to identify common, unique and rare species or varieties and helps to find reasons for their current status. This tool can help in selecting sites for on-farm and in-situ conservation projects. The tool helps to understand the status of diversity and to decide which type of interventions is needed for the conservation of specific species and varieties. When repeated over time (every three or five years) it can give valuable insight into the rate of loss of diversity in that specific area. The FCA tool (Sthapit *et al*., 2006) [40] was used to explore the distribution of common and unique crop varieties, including those of mandate crops for both native and improved crop varieties, FCA of mandate crops was done during site selection and community group discussion (Fig. 2).

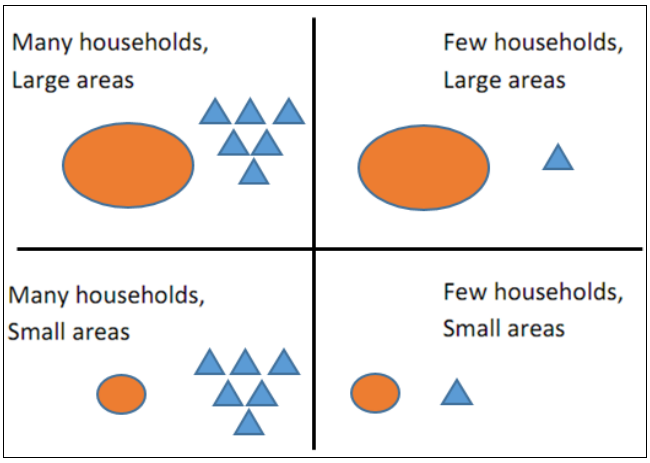

Fig: 2: Four cell analysis: a participatory method to access on-farm diversity status (Source: Sthapit *et al*., 2006)

Key Informant Interview

Key informant interviews were conducted among key community personnel, farmers, communities and KVK and NGO staff to gather additional information about the existing local crop diversities, seed systems, processing and management practices, available agricultural facilities and other related topics.

Community Transect Walk

Community transect walks were completed in all nine wards of the blocks to collect and validate the collected information regarding mandate crops. We take a sample of 10% in each project site (district) and each core, buffer and control village. A method of semi-randomization is applied within the village; we draw a grid on a map of the village with 4 pockets and start from the centre to interview every 7th house while walking on a Transact from the centre or close to the centre in four different directions. We interviewed people in their homes. If people were not at home we came back later.

We avoided starting a Transact with known contact persons closely associated with us. This should result in an incorrect representation of caste groups and wealth groups.

Household Questionnaire Survey

Sampled households from each ward were visited and after their approval, eligible members of the family were interviewed. A semi-structured questionnaire ODK application was used to collect household-level information on a tablet android mobile application questionnaire filled by interviewing each of the listed sample respondents. A well-being ranking of the household was not incorporated in the study deliberately to get generalized information.

The household survey was prepared by reviewing questionnaires of other similar projects, like the Strengthening the Scientific basis for on-farm Conservation of Agro-biodiversity (in-situ) project (Rana *et al*., 2000). The questionnaire was refined by incorporating the suggestions from the consulted experts and was pre-tested with a few sample farmers in core villages' viz., Nakna and Ghughra before field administration and finalized on ODK aggregate application (http://bioversityndo.org:8080/GEF baseline).

Sample Size and Sampling Procedure

The total number of households in the block and the name of the head of each house was collected through the active participation of the site coordinator and enumerator. In total, 2739 residing households were listed and a sample size of 273 was calculated as 10 % of a total household (Table1). Samplings were taken in the following ways.

- Multi-stage (cluster) sampling – in the first stage a sample of areas is chosen; in the second stage a sample of respondents within those areas is selected
- Panel sampling – questioning the same randomly selected group of people repetitive over a longer period.
- Probability Proportional to Size (PPS) sampling – sampling in which the selection probability for each element is set to be proportional to its size (% of the total population)

Table 1: Sampling of the household for a baseline survey.

Sr.	Name of site	Name of Village	No. of Household	No. of Baseline survey (10% HH)
1	Batauli	Nakna	310	31
2	Batauli	Dhekidoli	191	19
3	Batauli	Lalati	205	21
4	Batauli	Taragi	203	20
5	Batauli	Bataikela	423	42
6	Sonhat	Ghughra	319	32
7	Sonhat	Odari	181	18
8	Sonhat	Kailashpur	171	17
9	Sonhat	Vikrampur	92	9
10	Sonhat	Orgai	95	10
11	Sonhat	Katgodi	439	44
			2629	263

Data Entry, Cleaning and Analysis

Data entry was completed from the site office at the end of February 2019. Afterward, data were submitted on the ODK server and units of Bioversity International were standardized across the various surveys to allow for further data analysis. Explorative statistical analysis was done with Microsoft Excel 2013 and the ODK web analysis application. Various tables, graphs and charts were used to present the findings and were interpreted to meet the objectives of the research. Information gathered from FGDs, household surveys and secondary data sources were

consolidated and used to validate the results. Baseline survey data analysed through the ODK server (http://bioversityndo.org/). It is a screened filter designed for the collection of data with GPS tagging along with locations of respondents. The site coordinator prepared a questionnaire in the local language to identify the native name of the varieties and again translate into standard scientific names with the local name for transparent of data.

Fig 3: Diagrammatic representation of the process underlying the baseline HH questionnaire survey

Richness and Evenness: Richness and evenness are two key notions of biological diversity. Richness refers to the no. of different kinds of individual regardless of their frequencies. Evenness, however, measures how the similar frequencies of the different variants are with low evenness indicating dominance by one or a few types (Jervis *et al* 2008) [20].

Shannon Index: The Shannon index is derived from information theory and is based on rationale that diversity in a natural system can be measured in a similar way to the information contained in a code or massage (Magurran 1988 and Aguirre 1998) [24, 3].

Any index of evenness should reach a maximum when all species in a sample are equally abundant and should decrease towards zero as the relative abundance of species diverges (Ludwig and Reynolds 1988) [23]. Both the commonly used Shannon Evenness (also known as J') and Berger-Parker indices meet these criteria. The Shannon Evenness index is the ratio of the observed to the maximum diversity based on the Shannon index. The Shannon index is maximized when the total number of individuals in a sample is evenly distributed among the species represented in a sample. This maximum is given by the natural logarithm of the number of species. The Berger-Parker index is the inverse of the proportion of the sample occupied by the most abundant species.

Shannon Index $H' = \sum_{i=1}^{n} Pi - In\ Pi$
(i) (Richness and Evenness)

J Index $J=H'/InS$
(ii) (Evenness)

Berger Parker $D=1/(N_{max}/N)$
(iii) (Evenness)

Margalef Index $D = (S-1)/lnN$
(iv) (Richness)

Simpson's Index $D = \sum(\frac{n}{N})^2$ or $D = \frac{\sum(n(n-1)}{\sum N(N-1)}$
(v) (Richness and evenness)

Simpson's Diversity Indices: The term 'Simpson's Diversity Index' can actually refer to any one of 3 closely related indices.

1. **Simpson's Index (D):** Measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating D. either is acceptable, but be consistent. The value of D ranges between 0 and 1 with this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity.
2. **Simpson's Index of Diversity (1-D):** The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species. Another way of overcoming the problem of the counter-intuitive nature of Simpson's Index is to take the reciprocal of the Index.
3. **Simpson's Reciprocal Index (1 / D):** The value of this index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher the value, the greater the

diversity. The maximum value is the number of species (or other category being used) in the sample.

Results and Discussions

Crop Diversity Status and Trend

Interaction of participants of the FGD and several previous interactions during crop diversity fairs, champion farmers visit on the diversity of native varieties of rice crop two traditional varieties *viz.*, Agiyasal and Ruth dhan were almost extinct from Batauli block of Surguja and Hardigudi, Barijar, Kanakbas, mohbat from Sonhat block of Korea can be termed as extinct. Additionally, straw of all the rice varieties was stored and used as fodder purposes after harvesting and threshing. One of the major findings from FGD is the desirability of farmers towards the cultivation of hybrids particularly in rice, maize and vegetables due to their high yield potential and slightly they are neglecting their traditional/local varieties. This is a serious issue because most of the farmers were considered only higher grain yield and not preferring the better quality or other unique features of traditional varieties as nutritive value. Hybrids have no better quality and other unique features available as compare with traditional varieties. Although still some farmers of the area continuously growing aromatic short grain rice variety Jeeraphool and a nutritionally enriched rice variety Karhani for their home consumption purpose only.

Four cell analysis results illustrated into five components i.e. large area more household, small area more household, large area less household, a small area less household and fifth represented extinction of crop varieties which was not existing at the site but before ten years was under cultivation. Batauli and Sonhat block of the sites were analogous in popular variety Jeeraphool, Karhani and some pulses and oilseeds but some rice varieties were differed due to its nativity of the regions. More household cultivating hybrids and improved variety along with Jeeraphool in rice crop but native varieties were found in pulses, oilseed crops. Many households were found small landholding cultivating some improved varieties IR-64, MTU-1010 in rice crop while wheat variety as Lok 1 and 1553 local variety. Some less household were cultivating native/indigenous varieties as Ganga Prasad, Karhani, Rani Kajal, Vishnubhod and Chindmaouri in rice crop. Many native landraces and less improved variety ASHA, Rajiv Lochan and Azad-3 of Pigeonpea varieties were found in the Batauli block as well as Sonhat block. In case of oilseeds, Lutani sarso was found very popular in mustard comparison to yellow mustard due to short duration with high oil content. Some groundnut local variety Do Dana, Teen Dana was cultivating by fewer households in large area.

The high number of native varieties were found under the class of fewer households in small area and some varieties were found endangered due to lacking of farmers' choice in desire of yield advantage (Fig.3). There are some defects in native varieties as very late maturity (>150 days), tall stature (>140cm) prone to lodging and low yielder. FGD respondents demanded those varieties to revive under small areas fewer households. Some unique native varieties still cultivating due to its medicinal property like Karhani variety was used by many farmers to cure Anemia and many other problems as therapeutic use as per their traditional knowledge. It is also reported as high iron content in traditional varieties by Singh et. al. 2015. Most of these varieties are tolerant to biotic and abiotic stresses and have some unique properties viz., higher Iron and Zink content. These rice varieties have good taste and other unique features as compare to modern varieties and it is very difficult to rank them depending upon the information of the farmers. Twenty percent of households in Batauli block cultivating only Jeeraphool Rice while Nine percentage households were cultivating only Karhani Rice, but 11 % household cultivating Jeeraphool and Karhani both varieties. The highest figure was found as 34 % household hybrids and other improved varieties due to the desire of high yield at the Batauli block of Surguja (Fig.4).

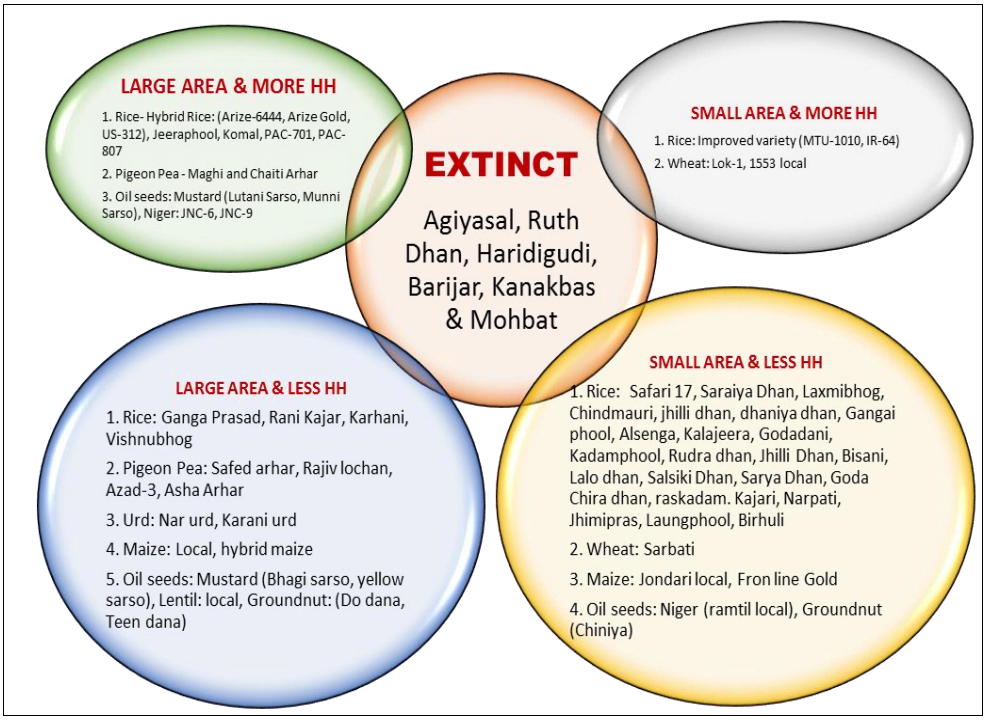

Fig 4: Focal group discussion on crop diversity (Four cell analysis)

Among improved high yielding varieties only 19 % of households were cultivating MTU-1010, 28 % Household cultivating Komal rice variety (It is private sector improved variety) while only 10% IR 36 rice variety at Bautauli block of Surguja (Fig4). Whereas at Sonhat site 39 % of the household were cultivating only Jeeraphool Rice, 9 % household cultivating both Jeeraphool and Sanchuriya Rice, 5 % of household cultivating only Sanchuriya Rice, 7 % household cultivating Jeeraphool, Karhani, Sanchuriya and Kanak Bas (native aromatic varieties) rice for home consumption and 15 % household cultivating hybrids and other improved varieties for sell to cooperative societies and state government procurement agencies (Fig4).

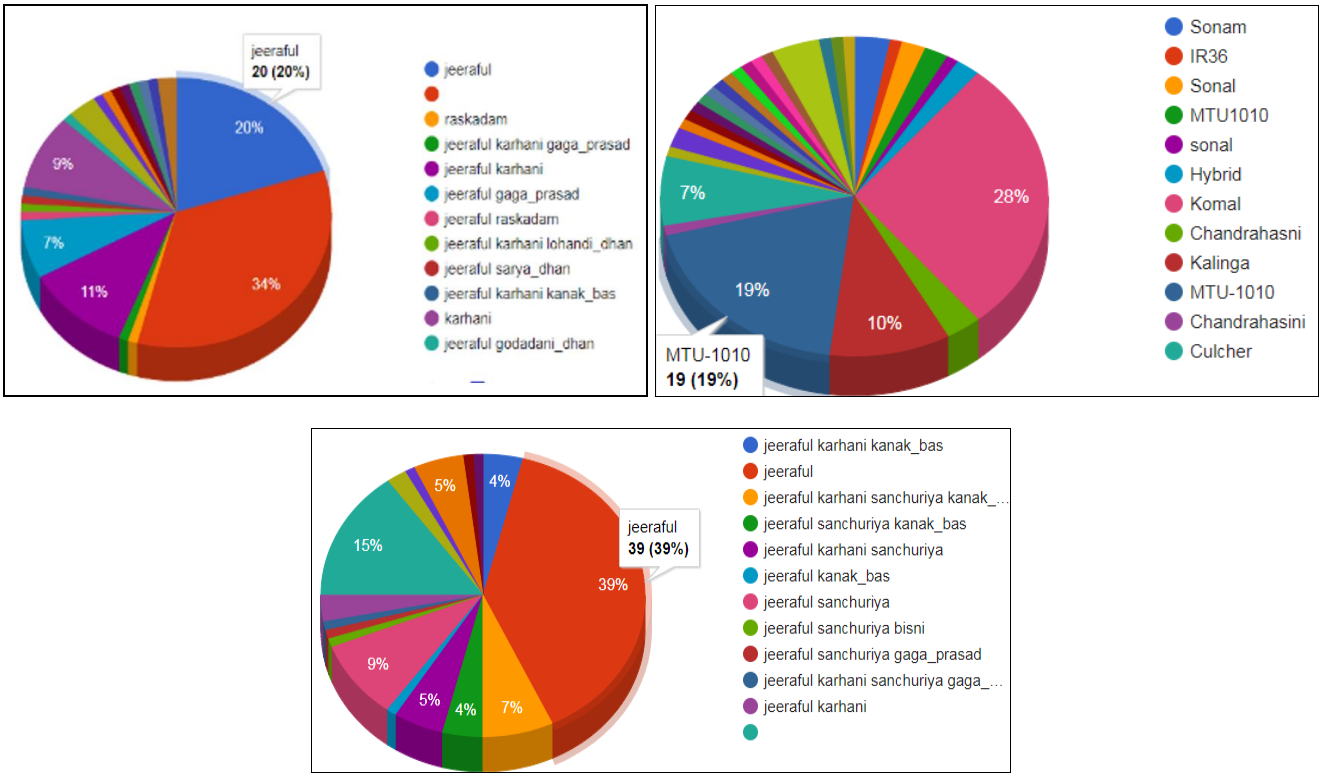

Fig 5: Crop diversity household wise status and frequencies at the sites

It is widely expected that patterns of diversity reflect differences in climate, altitude and other agro-ecological factors. Batauli block also covers a wide range of altitudinal variation and holds different micro-climatic conditions that have supported noteworthy crop and varietal diversity. The overall inter-specific crop diversity of the Batauli is quite rich, especially in rice and mustard crops. Local micro-environments created by altitudinal variation provide suitable settings for the continuous evolution of crop cultivars resulting in a wide range of local landraces. However, two mandate crops, Kodo millet and little millet have not been recorded during the baseline study and were not common even in the past. Furthermore, intraspecific diversity within the commonly grown mandate crops is high in Batauli.

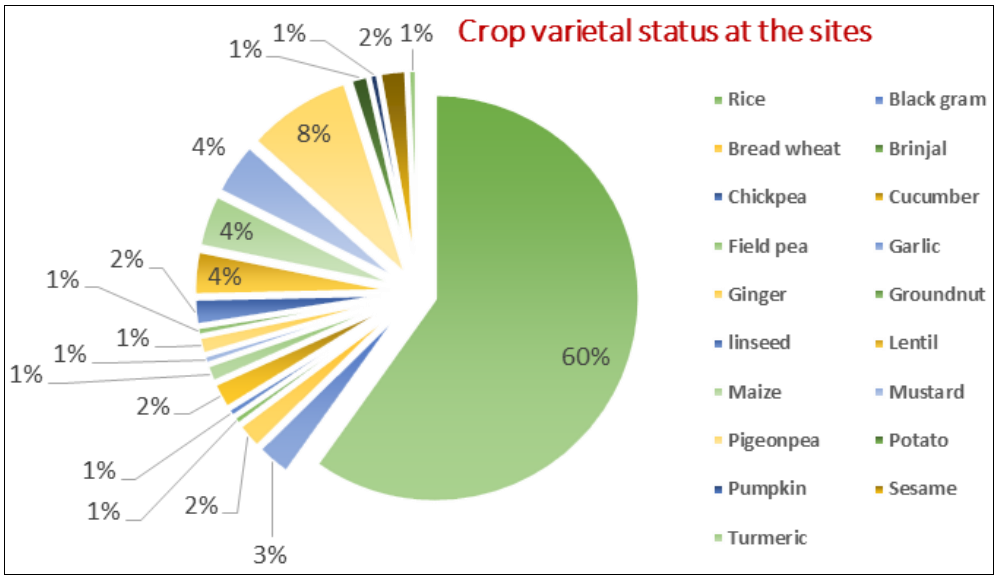

Fig 6: Crop variety trends and status

The assessment of diversity provides the necessary description of the extent and distribution of genetic diversity of traditional varieties and of how that diversity is partitioned within and among varieties at household and community levels. Research has provided substantial evidence that significant crop genetic diversity continues to be maintained at farmers' fields in the form of traditional varieties (Brush, 1995; Jarvis *et al*., 2004; Bezancon *et al*., 2009; Bisht *et al*., 2007; FAO, 2010). Though the extent of varietal diversity cannot be assessed only by a farmer named varieties because the same variety may have different names depending upon locality (Rana *et al*., 2000). Local farmer selects suitable landraces/varieties for their farmlands and maintains household level varietal richness which is a good indicator of recognizing and utilizing agro-biodiversity at the local level. Mandate crops having higher varietal richness also have higher evenness value (especially in pulses) indicating evenly distributed varietal diversity within the village. In the case of Buckwheat, only two varieties exist viz., Tau-1 and Tau-2 (Local selections) with the latter being more dominant. For black gram and minor millets, diversity deployment is needed to increase the cultivation area and reduce the dominancy of the few varieties. Agricultural system of Batauli and Sonhat is traditionally well adapted to the local agro-climatic and geographical conditions by maintaining local crop varietal diversity. High varietal richness and evenness are due to traditions and rich traditional knowledge associated with local agro-biodiversity. Identification, documentation and release of the most promising local varieties will be areas of intervention in the crop improvement program to reduce plant height and duration. 17 registered farmers' varieties at the site of Korea and 142 varieties from the Batauli block depicted richness of diversity (Fig. 5)

Table 2: Spatial Diversity Indices on crop diversity at target sites.

Sites	Crop Richness	Shanon Index	J' Index	Simpson Index (D)	Simpson's Index of Diversity	Simpson's Reciprocal Index	Margalef Index	Berger Parker
Batauli	11	1.184	0.494	0.617	0.383	1.621	2.323	1.276
Sonhat	10	0.862	0.374	0.323	0.677	3.100	2.621	1.824

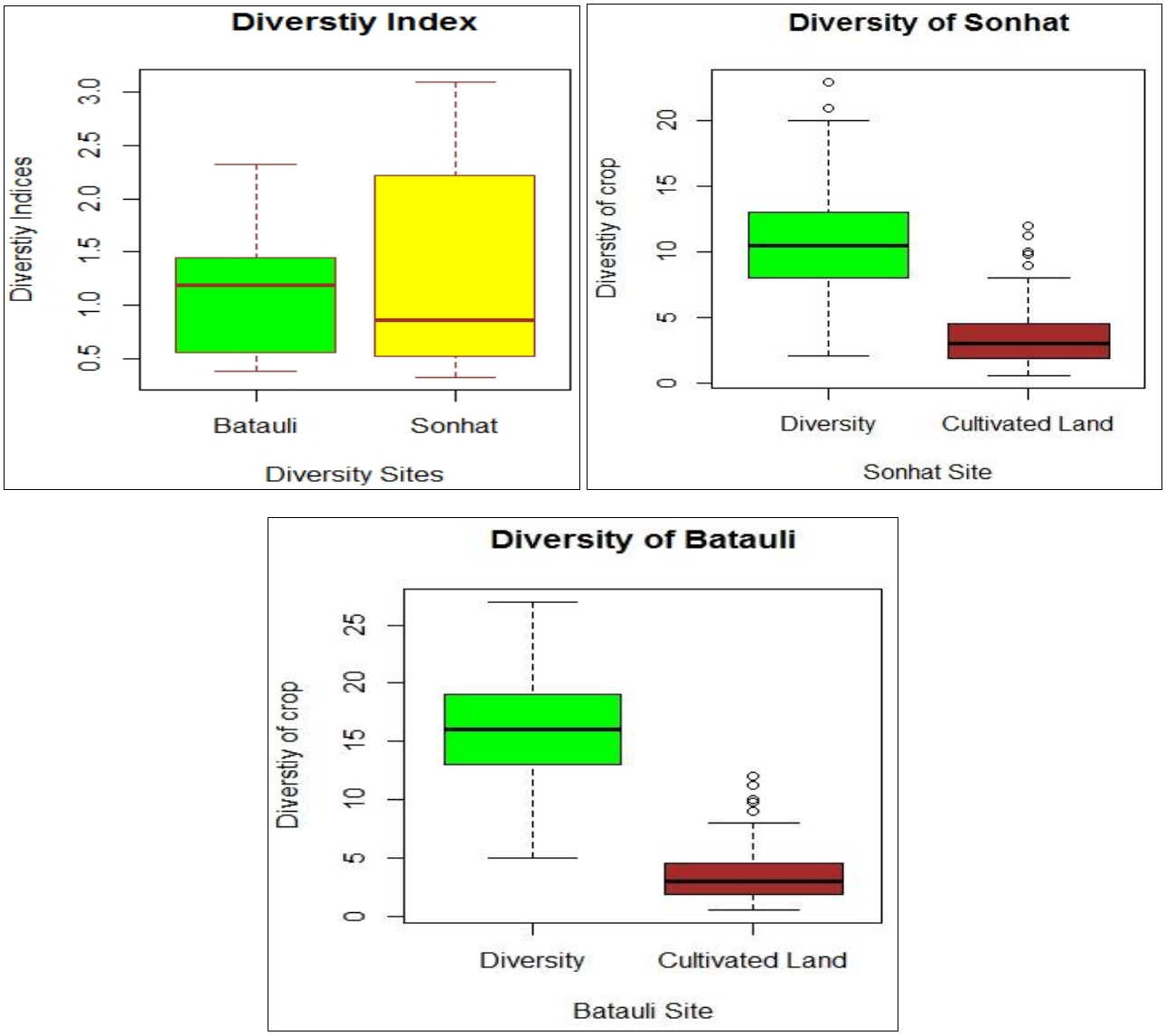

Fig 7: Box plot of diversity index and cultivated land with crop diversity at target sites.

The diversity indices constructed from data on crop varieties, however, consistently site of Sonhat (0.677) at a higher level of diversity than Batauli (0.383). This finding also holds strongly when comparing the richness and dominance indices based on morphological groups, The Simpson and Shannon diversity indices, which express both richness and evenness in a single indicator, Sonhat>Batauli and also compared to the rankings based on the Margalef index. Box plot analysis depicted the larger box of sonhat than Batuli due to Simpson's diversity of index (Fig. 6).

Existing diversity in mandate crops

Six of the eight mandate crops are grown in Batauli & Sonhat block while only traditional varieties of grain amaranth and buckwheat were grown by the farmers at Manpat and northern parts of Batauli. Amaranth is found, but it is uncultivated and grows traditionally. Instead, it regenerates and dies on its natural cycle and is occasionally consumed as a green leafy vegetable. Varietal richness has been recorded from two separate collection methods (FGD Four Cell Analysis and baseline survey methods), the highest varietal richness was found in rice followed by Pigeon pea and mustard. In all crops, local/native varietal wealth is higher than modern/released/improved varieties. These studies indicated that the Batauli block is rich in local landraces of mandate crops.

The household-level richness and overall evenness are highest in black gram varieties, while community-level richness is highest in rice followed by mustard and pigeon pea. In terms of household-level evenness, black gram ranked third, after rice and pigeon pea. Among all explored mandate crops of the project, black gram and pigeon pea are the most commonly cultivated crops in small areas and also have the lowest productivity indicating their important contribution to food security in the Batauli block. Rice crops have the highest varietal richness, which indicates that farmers of Batauli & Sonhat have given priority to maintaining the diversity of their widely cultivated crops. Black gram and pigeon pea native varieties are cultivated by many households only in a small area or in the kitchen garden (tribal people nominated as cultivation in *Bari)*.

All the farmers of Batauli and Sonhat are primarily engaged in cultivation with fairly good knowledge of varieties and their traits and also stored some of the rare varieties. Around 20-25% of farmers have very good traditional knowledge of local varieties and their traits and actively conserved many rare varieties. Seeds are available only with the custodian farmers. The improved varieties of the targeted crops are made available from IGKV, Raipur (mostly procured by the farmers and sometimes provided by the concerned KVKs under different schemes). The state agriculture department also provided the seeds of different crops during crop season directly or through the concerned KVKs under different schemes.

Unique native varieties viz., Jeeraphul, Kalajeera, Bisni, Vishnubhog, Ganga Prasad, Chindmaori, Rudra Dhan, Alsenga Dhan, Janjale Dhan, Arend Kadamphool, Arend Karhani, Godadani Dhan-1, Jhilli Dhan-1, Lallo Dhan, Raskadam, Gangai Phool, Sarya Dhan, Jhalsiki Dhan in paddy crop from Ambikapur and Maghi arhar, Chaiti arhar in pulses from both Batauli and Sonhat sites were identified while Karahni, Jeeraphul, Sanchuriya, Lohandi Dhan, Veerhuli dhan, Kanak Bas, Jhunni Prasad paddy varieties were found at sonhat site. Among these, the best ones were Jeeraphul, Karhani, Sanchuriya rice varieties. Karhani (having high iron >20ppm and zinc content >32ppm) medicinal rice variety reported by Singh *et al*. 2015 [38]. Production and marketing group has been constituted to increase the income of farmers and also to sustain their livelihood as baby food for lactating mothers in tribal women in Surguja. Crop preference depends on its utilization, tradition and culture of the local community. Ethnicity also plays a determining role in defining crop utilization. Minor crops are neglected and underutilized due to socio-cultural norms/tradition, changing food habits and availability of better options in other crops (partly due to greater research investment in them). Cultural importance and medicinal values of certain crops lead to the existence of certain crops in the community despite limited utilization in daily life.

Seed sources and management practices in mandate crops

Farmers access seed through formal and informal systems. A system is formal if the seeds are traceable to its origin in the system. This is usually applicable for certified seeds of notified varieties, which require a label that allows for tracing to the source. On the other hand, a system is considered informal if the seeds are difficult to trace the origin using a paper trail as seeds do not require a label. Local markets such as Haat Bazaar can be seed sources for both formal and informal sectors depending on whether the seed is sold with or without labels. The seed system for mandate crops in Batauli and Sonhat is mostly local and informal. At Sonhat, informal seed sources included farm-saved seeds, seeds obtained from neighbors or relatives and Haat Bazaar, whereas formal seed sources viz. communities, government agencies, NGOs and cooperatives (Jarvis *et al*. 2005). More than 60% of households within Batauli keep their seed for the next planting season for all mandate crops. A total of five different seed sources were recorded with the largest contributing seed source being a farmer's source followed by neighbors and relatives. About 70% of the household's annual seed use is met by their farm-saved seed. *Urao* tribal families (*Urao* families are scheduled tribes of batauli block in Surguja district) were found to rely more than average on outside sources, other backward families were found to rely more on the self-saved seed. Chhattisgarh informal seed system *Charjhania* is most popular in the tribal communities to share and conserve native varieties in the communities.

Charjhania

It is an informal seed system to conserve and protect the native/traditional varieties at the community level. It is a traditional practice of seed conservation and distribution in the tribal dominating region of Chhattisgarh state. This concept arises with its name as *Charjhania* means the involvement of four persons. It's a plead by each recipient to distribute the same seed to another four persons and these four persons are committed to share or distribute the same seed to another four persons. Therefore, seeds are continuous multiplied as chain and distributed in the multiplication of four persons by which adequate amount of seeds are being available at the community level

Farmers predominantly use the informal seed system and lack a wider network and linkage with formal seed sources. There is a weak connection between informal and formal

seed systems which is important to strengthen. Access to quality seeds of traditional varieties is often limited within the community due to the exclusion of local crops in development programs. There is also an indication that access to diversity and the quality of seeds is relatively more struggle for tribal households. Studies have indicated that access to information, social networks and institutional mechanisms for collective actions are necessary for strong seed systems (Sthapit *et al*. 1996; Shrestha *et al*., 2006). Recent studies that quantify the amounts of farmers' own saved seeds versus seeds obtained from friends, relatives, neighbors or local markets show that farmers prefer to save their seeds in most situations (Gildemacher *et al*., 2009; Rana *et al*., 2008; Hodgkin *et al*., 2007; Lipper *et al*., 2010) [15, 34, 17, 21]. Therefore, adding diversity and strengthening the informal seed sources can be an area of intervention. This can be achieved by mobilizing and empowering local organizations by employing BMC (Biodiversity Management Committee) principles. Expanding seed exchange networks through organizing Participatory Seed Exchange (PSE) can quickly make the existing diversity in the village more widely available. Identification of custodian farmers and dissemination of seed related knowledge through diversity fair and distributing diversity kits would be relevant to enhance coverage of new crop diversity. Furthermore, the establishment of Community Seed Bank (CSB) will be effective in linking formal and informal seed sources and make local seed systems more resilient which is also suggested by Mazhar (2000) [27] and Sthapit *et al*. (2006a) [41].

Seed system of mandate crops

The seed system is composed of individuals, networks, institutions and organizations involved in the development, multiplication, processing, storage, distribution and marketing of seeds (Maredia and Howard, 1998; Loch and Boyce, 2003) [25, 22]. In Batauli, farmers managed seed system is prevalent in all traditional crops including the project's mandate crops. According to Almekinders and Louwaars (2002) [4], the local seed system also relies on traditional management practices of crops and seeds playing a role in allowing landraces/varieties to evolve in the local environment. As a result farmers' knowledge and management practices like selection, harvesting, drying and storing play a key role in determining seed quality, production status and ultimately shaping the genetic diversity of crop varieties. Farmer managed seed systems have a significant role in allowing landraces/varieties to evolve in a local environment, thus making them important contributors to the management of global plant genetic resources for food and agriculture (FAO, 1998) [10].

Existing local groups/organizations

Through community group discussions, a local level organizational listing was created that included the scope (in terms of members/ household coverage) and major activities and each community organization. A total of 6 cooperatives and 9 women's groups were recorded. Saving and credit schemes are the most common and primary activities of all groups/organizations. However, agriculture cooperatives and a multipurpose cooperative have undertaken a few agricultures related activities, including off-season vegetable farming, bean grain production, and marketing. Most of the community groups have focused on the major objectives mentioned in their legal documents. The majority of social groups in the villages are currently inactive. Though 5 farmer groups have been registered in Batauli block, one self-help group "Jaivik Krishi Utpadak Sahkari Samiti Maryadit" currently dormant working for the production and processing of Jeeraphool rice.

Jeeraphool Rice is the most prevalent, ceremonial and excellent eating quality scented rice of the Surguja district in Chhattisgarh state. It is famous for its aromatic flavor, flakiness and taste. The name "Jeeraphool" derived due the It's rice looks like a cumin shape. The geographical area of production of Jeeraphool rice includes the districts of the Surguja division of Chhattisgarh state, which is comprised of Surguja, Surajpur, Koriya, Jashpur and Balrampur districts. The unique aroma in the Jeeraphool grain comes only when it is grown in a few blocks viz. Batauli, Ambikapur, Lakhanpur, Udaipur, Sitapur, Lundra and Mainpat part of the district. Many farmers groups and other commodities have taken priority to produce Jeeraphool in the large area due to more than two times the price increased after the GI grant of Jeeraphool. The area of Jeeraphool is increased from 400 ha. To 1080 ha. and production from 1800 quintal to >10000 quintals in the Surguja district only (Tigga and Singh. 2018 and Tigga *et al*. 2018) [43, 42]. The export of Jeeraphool rice is demanded in overseas countries and supplying to all metro cities of India. Many millers and rice seller companies purchasing Jeeraphool rice from the farmer's self-help groups on spot case and also through advance payment booking during the crop period at the farmers' field. Therefore farmers are benefited more than two times income through the cultivation of Jeeraphool rice. Jeeraphool rice registered as GI product on dated 11 March 2019 with GI no. 611 by Geographical Indication Registry, Chennai and Intellectual Property Right Authority Govt. of India.
(http://ipindiaservices.gov.in/GirPublic/Application/Details/611)

Conclusion

Sonhat holds rich varietal diversity in landraces of mandate crops, there is a huge possibility of identification of most promising varieties in terms of production, disease and climatic stress-tolerant trait (climate-resilient) and improvement in traditional variety (especially in tall and late rice varieties). Tribal farmers are curiously expecting to improve such landraces which are culturally attached with native varieties having some deficiencies under the stage of endangered due to lodging and late maturity without alteration of their original grain quality. Hence, we have initiated a mega program to improve such varieties through mutation breeding with the collaboration of the Bhaba Atomic Research Center (BARC, Mumbai). We are trying to introduce some varieties viz. Dwarf Dubraj, dwarf Safri-17 and dwarf Luchai through Mutation breeding program; Indira Barani Dhan-1 and RRF 105 drought-resistant varieties through drought breeding program and Indira Madhuraj-55 (Anti-diabetic rice), Chhattisgarh Zink Rice-1 and 2, Zinco (High Zink rice) and Protazina (high Protein rice) through Bio-fortification program Local version of these varieties are almost extinct or near to extinction but now revived through improved of similar type of its improved counterpart. Sonhat block is connected with road network up to district headquarter at Baikunthpur city (Korea), viable technology introduction, local product

transportation and developing market linkage should be economic, reliable and full of scopes. Establishment of processing units to prepare local food products viz., flaked rice, puffed rice, Multigrain flour, various pulses products, oils will be beneficial to link-local varieties with markets.

There are several stalk holders exist in the Surguja which can be mobilized in sensitization about valuing local crops, establishing Community Seed Bank for conservation and seed production, value addition and marketing of local crops with local branding. Diversity can help farmers mitigate, adapt and ensure food and nutrition security by providing them with more options to manage climate risks and strengthen the resilience of their farms and surrounding landscapes.

There is an urgent need to promote, revive indigenous crop varieties and reverse the loss of agro-biodiversity caused due to market drivers. Indigenous crops are more resilient to climate variations, farmers have a better knowledge of handling them and traditional crops generally meet the food preferences of communities, making it all the more important to create measures to promote and revive them.

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