A sticker on a woman's door in Madhya Pradesh reminds her to weed her millet field. Credit S. Priyam/ ASA

Factors linked to millet cultivation and adoption of improved cultivation practices in eastern Madhya Pradesh

A case study in the programme "Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk"

Shambhavi Priyam

Contents

Contributors

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Abbreviations

A4NH	CGIAR Research Programme on Agriculture for Nutrition and Health
CCAFS	CGIAR Research Programme on Climate Change, Agriculture, and Food Security
CGIAR	Consultative Group for International Agricultural Research
ASA	Action for Social Advancement
IFAD	International Fund for agricultural development
KVK	Krishi Vigyan Kendra
NGO	Non-governmental organization
PDS	Public Distribution System of India
POP	Package of best practices for millet cultivation
Project	The IFAD and EU supported initiative “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk”
SHG	Self-Help Group
SMS	Short Message Service
SRI	Sustainable Rice Intensification
SWI	Sustainable Wheat Intensification
VRP	Village Resource Person

Executive summary

As in several other areas of India, there has been a shift in agricultural patterns in Madhya Pradesh in recent decades as much of the region has turned toward growing paddy instead of traditional minor millets. This has caused a loss of biodiversity in the region and leaves the farming systems more fragile in facing climate change. Through the Project "Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk", supported by the International Fund for Agricultural Development (IFAD) and the European Union from 2015 to 2018, Bioversity International and Action for Social Advancement (ASA) have been taking action to reverse the decline of millet cultivation in Madhya Pradesh to support climate change adaptation and build more resilient, nutritious food systems.

The Project focuses on the entire value chain of millets from increasing supply to creating demand. This case study focused mainly on the supply aspect. Minor millets tend to have low yields due to poor seed quality and inefficient production practices. Agricultural technology such as Sustainable Rice Intensification (SRI, Uphoff and Kassam 2009) and Sustainable Wheat Intensification (SWI) have substantially helped increase the supply of these grains. A similar set of best practices for minor millets thus might be revolutionary in terms of restoring both biodiversity and increasing supply of millets. Enhanced cultivation practices for millets in Madhya Pradesh have been developed in recent years and are being promoted in the Project communities by training farmers on the techniques through their local self-help groups.

This study explored some socioeconomic and psychological factors related to the adoption of millet cultivation and the improved cultivation practices being promoted. The analysis highlighted some factors linked to higher millet cultivation in Dindori district, where farmers have larger but more marginal landholdings and higher rates of migration as compared to Mandla district. In Mandla, landholdings are smaller but more suitable to rice cultivation, which has enabled the abandonment of traditional millets. While millet cultivation was more common in Dindori, farmers in this region were more hesitant to adopt the promoted package of practices because of high risk aversion. The indices for income, health and education constructed in this study formulate a good resource for assessment of conditions in the region however, further tuning is necessary to improve the capacity of these indices to capture the most relevant indicators of income, health and education in the region.

This study is a first of its kind trying to combine the insight of behavioural sciences with the agro-economics of the Mandla and Dindori area. Using an approach informed by behavioural economics (Rothman et al 1997, Laitner 2000, Noll & Krier 2000, Burton et al 2006, Gowdy 2008, Allcott & Mullainathan 2010, OECD 2012), a small random control trial was conducted that assessed the effectiveness of a behaviour "nudge" in the form of a sticker to induce farmers' motivation and attention to weeding their millet fields. The results showed a significant effect of the sticker. This case study underlines the value of building understanding of farmers' psychology and socio-economic situation to inform better approaches and practices and induce ripples of change.

Introduction

Minor millets are central to the traditional farm and food systems of indigenous Gond farmers in hilly districts of eastern Madhya Pradesh, where rainfed crops are relied on for subsistence. Millets can survive under the harsh conditions of this region where there are limited irrigation facilities, thin topsoil, and the ground is filled with large rocks. Traditionally millets were the major staple in this region and they were cultivated and consumed in abundance. Paddy was more rarely grown and was considered a delicacy affordable only by the rich. More recently, with the implementation of the Public Distribution System (PDS), the government has been providing rice and wheat at subsidized rates for low income households. Threshing and manual post-harvest processing of millets is highly labour intensive and after hours of using a hand grinder, it is not uncommon for people to find specks of dirt when they eat food prepared with millets. The easy availability of rice from the PDS has discouraged the consumption of millets, while new technologies for rice have been developed and promoted, encouraging farmers to give greater emphasis to cultivating paddy. In *kharif* season, paddy is grown in low elevations where moisture is greatest, maize is cultivated on more gentle slopes, while kodo millet (*Paspalum scrobiculatum*) and kutki millet (*Panicum sumatrense*) are grown only in the steepest areas.

Kutki millet in eastern Madhya Pradesh. Credit S. Priyam/ ASA

In the wake of climate change, eastern Madhya Pradesh is seeing evident changes in weather patterns and the rain cycle and the emphasis on paddy over climate-hardy millets is putting communities at risk of crop failures. In 2015 this region recorded rainfall at 29% of normal levels, resulting in yield declines and loss of the *rabi* crop that required the state to seek financial support to mitigate rural distress (Bera 2015). Maintaining and enhancing the cultivation of millets can build resilience of these systems to climate change. However, it can be a challenge to modify the behaviour of a society which is changing quickly in terms of socio-economic conditions and social norms. Through the Project “Linking agrobiodiversity value chains, climate adaptation and nutrition: Empowering the poor to manage risk”, supported by IFAD and the European Union from 2015 to 2018, Bioversity International and ASA are taking action to reverse the decline of millet cultivation in Madhya Pradesh to support climate change adaptation. The Project is addressing critical bottlenecks in the production, processing and value chains of these hardy traditional crops that have been leading to their abandonment.

Enhanced cultivation practices

The traditional practice for millet cultivation in eastern Madhya Pradesh involves simple broadcasting of seed, no use of fertilizer or manure, and limited attention to weeding (as priority for weeding is given to paddy). The millets grow side by side with other grasses, herbs, and unwanted weeds, which compete for light and nutrients. To enhance the yield of millets in this area, ASA is promoting a package of best

practices for millet cultivation (POP) that was developed through field experiments by Krishi Vigyan Kendra (KVK), Dindori from 2011 to 2014. Line sowing and weeding are key practices promoted in the POP. Line sowing makes weeding easier and provides ample space for wind to pass through the field without felling the plants. Weeding removes competing vegetation, ensuring ample supply of space, light and nutrients for the millets. Adding organic fertilizers (cow urine, cow dung, chickpea flour, and jiggery) is another component of the POP that enhances nutrient availability for the crops.

To adopt or not to adopt the POP

Not all farmers in the trainings were eager to apply the POP for millet cultivation. Reluctance to adopt the practices could relate to factors associated with their income, health and education. Farmers with larger landholdings and higher incomes (often cultivating paddy) may be reluctant to adopt the POP because of lower dependence on millets for subsistence. Farming millets can be more labour intensive than farming paddy as it is cultivated on hill slopes and the threshing procedure is particularly labour intensive, requiring multiple rounds. Even greater effort is involved in line sowing as compared to broadcasting, which may present a barrier to millet cultivation and use of the POP. The education level of the farmers could also be a factor, even though the training did not involve a highly technical or calculation-based procedure.

In addition of socio-economic factors, another factor leading to non-adoption of the POP could be limited time and mental resources of the farmers. It is often assumed that the resources which are limited for farmers are in terms of their economic and financial capacity. However, in several cases, it is their mental resources which are limited (Datta et al 2014), such as their attention span. In the training sessions, the farmers learned about the importance of millets for adapting to climate change but addressing distant future needs may have lower prominence in their daily-decision making as they work to meet their immediate current-day needs. While the farmers may have understood the importance of cultivating millets and the POP for climate resilience, they may eventually forget to apply these practices as time goes by after the training. Personalized reminders have been seen to work well with consumers of particular services (e.g. savings; Karlan et al 2016) and there have been several attempts to employ SMS systems to remind people to adhere to behaviour for which they have opted (e.g. water conservation techniques; Data et al 2015). Such a reminder approach could also be effective in encouraging adoption of good practices for millet cultivation.

Farmer from Tikraberpani village in Mandla harvests little millet. Credit S. Priyam/ ASA

This study aimed to build understanding of the challenges to adoption of millet cultivation and the POP among the farmers in the study area in order to help identify approaches to improve the suitability of the POP, encourage adoption of the good practices, and enhance the role of millets in the livelihoods of these farming communities. The first part of this study related the cultivation of millets and adoption of the POP to indices for income, health and education. The second part of the study involved a small-scale randomized

control trial investigating the effectiveness of behavioural nudges for incentivizing farmers to adopt best practices for millet cultivation. The study looked to replicate the methodology of positive subconscious reinforcement applied in other behavioural studies (e.g. Alcott et al 2010). This study also gathers initial reactions of the farming community to the POP to narrow down causes for reluctance to adopt these practices and identify more suitable approaches and technologies.

Study Area

The Project is targeting thirty villages in three blocks in Madhya Pradesh. The target blocks are Shahpura and Mehandwani in Dindori District and Mandla in Mandla District (Figures 1 and 2). The area receives about 2100m of rainfall annually, has medium to shallow soil and 61% forest cover. Most of the families in the area belong to the Gond tribe. The population is 77% scheduled tribes (ST), 4% scheduled castes (SC), and 19% others. Local livelihoods are dependent on agriculture, as they grow most of the food they have to eat. Farmers have more recently started selling some of their production in order to increase their household incomes. Table 1 provides basic information about of the region.

Table 1. General statistics about the regions of Mandla and Dindori where the study was conducted

Indicator	*Mandla*	*Dindori*
Area (km^2)[a, b]	8771	7470
Literacy of total population in 2001 (%)[a, b]	60	54
Population of scheduled tribes (%)[a, b]	57.23	64
Literacy among scheduled tribes (%)[a, b]	51	49
Population per health care center in 2006 (#)[c]	2720	3333
% area under forest [d]	49	37

[a] Mandla District Administration nd, [b] Census of India 2011, [c] Directorate of Health Services 2007, [d] Forest Services of India 2011

The baseline study revealed that millet cultivation was most common in Shahpura block, intermediate in Mehandwani and least common in Mandla (Bioversity International and ASA 2017). Millets were primarily oriented to subsistence but some commercial production of millet was occurring—especially in Mandla district. Production was more oriented to kutki millet in Mandla, which receives a higher market price than kodo. In Dindori district special emphasis was given to kodo millet.

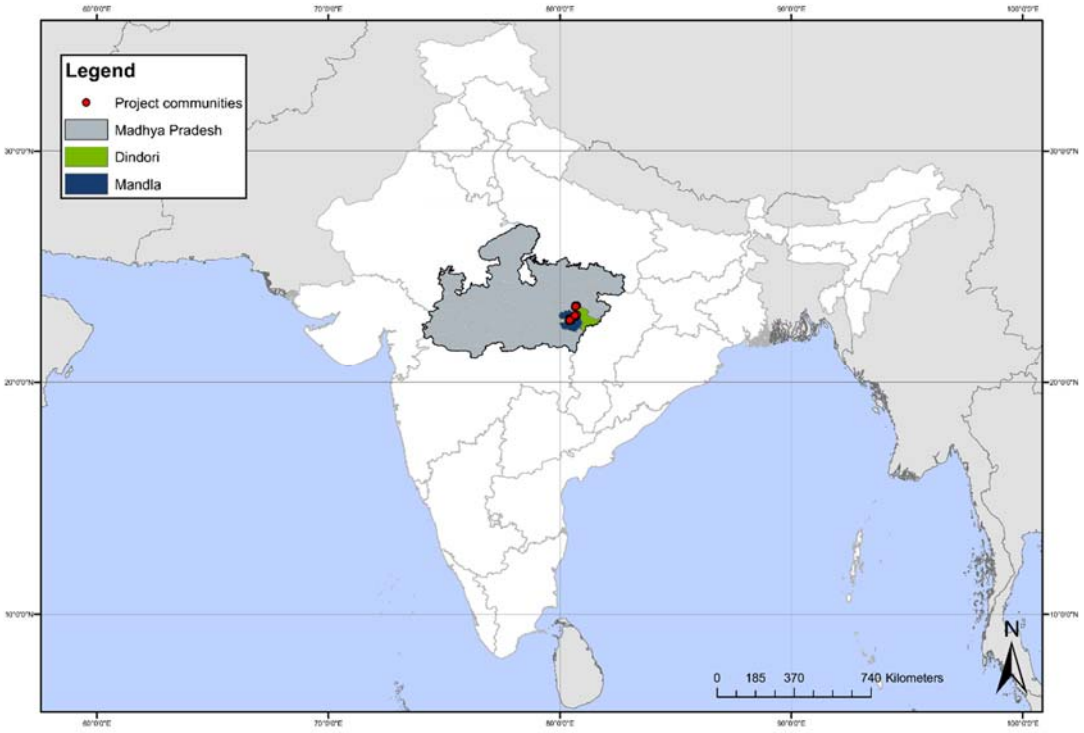

Figure 1. Target sites of the IFAD-EU NUS Project in Madhya Pradesh, India.

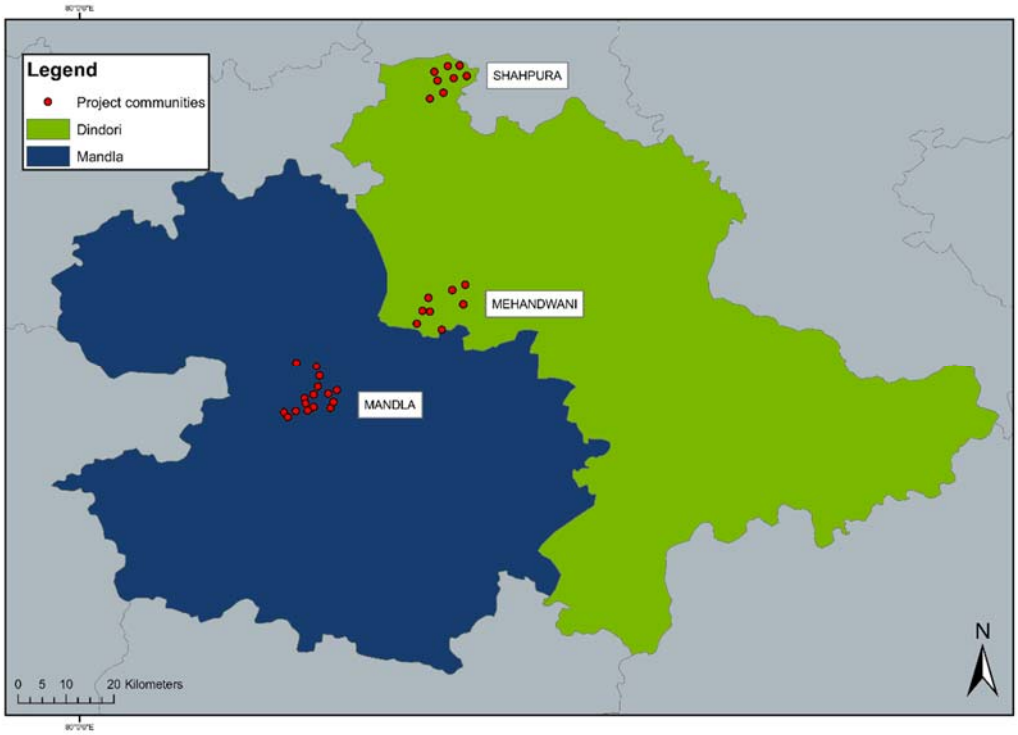

Figure 2. Targeted villages and blocks in Mandla and Dindori districts of Madhya Pradesh, India

Methods

Training on the POP

Farmers in the 30 Project villages in Mandla, Shahpura and Mehandwani blocks of Madhya Pradesh were trained on the improved POP for millet cultivation (Table 2). The training was given through their self-help group (SHG) by a village resource person who was trained by ASA. A total of 149 self-help groups with a total of 1872 members were trained in the 30 communities. The village resource people (VRP) conducted meetings of the self-help group members on a bi-monthly basis during which a session was dedicated to learning farming techniques. The farmers were given millet seed of local varieties in addition to the training.

Table 2. The POP instructed to farmers in Mandla and Dindori districts Madhya Pradesh

Practice	*Description*	*Benefits*
High quality seed	Use of newer seeds.	The quality of seeds available with the farmers is generally of substandard level. They are often very old seeds that have stayed with the farmers or their families for several years.
Line sowing	Singular seeds are planted one after another in a straight line format.	Instead of simply broadcasting the seeds on a patch of land this leaves greater space for weeds to grow and thus weeding would be easier.
Weeding	Rooting out the unwanted plants, herbs, and other grasses in the millet fields.	Leaves more light and nutrients to be utilized by the millet crops
Organic fertilizers	The usage of organic fertilizers made using simple household items such as jaggery, lentil flour, cow dung, cow urine.	Aids the production and output of the crops. Compared to chemical fertilizers, they are cheaper to procure and do not harm the soil or the nearby environment.
Organic pesticides	The usage of organic pesticides made using simple household items like neem oil, garlic, peppers, etc.	Aid the production and output of the crops. Compared to chemical pesticides, they are cheaper to procure and do not harm the soil or the nearby environment.

Social factors linked to millet cultivation and adoption of the POP

For the first part of the study, the cultivation of millets and adoption of the POP was related to indicators of income, health, and education for 120 households in the study area. Data on cultivation of millets was collected for 120 households in eight of the Project villages spanning the three focal blocks (Table 3). Households were selected randomly, balancing from different neighbourhoods in the focal villages, because they were at different distances and levels of socioeconomic development in larger settlements. Focus

groups were carried out in each block to gather complementary information about factors linked to cultivation of millets and adoption of the promoted POP.

Table 3. Villages and sample size for the household survey on millet cultivation and adopting of the POP in each focal block

Block	*Villages surveyed*	*Sample size*
Mandla	Silpuri, Tikraberbani, Kudopani	40
Mehandwani	Chanta, Devgarh, Kathotiya	41
Shahpura	Bhilai, Khrushipar	39

Indices for income, health and education were constructed by scoring a set of related indicators using defined weights for different thresholds and states. The variables within in each index were given equal weight and their mean was calculated to give a score ranging from 1 to 10. The index for income considered the size of households' landholdings, whether they had family members migrating for paid work, and the number of income types in the household (Table 4). The index for health considered if there had been a premature death in the family in the past five years, the distance to access a healthcare facility, the number of family members on medication or with prolonged health issues, and the number of family member who were malnourished (Table 5). The index for education considered the grade completed in formal education for all the family members, which was scored and averaged over the total number of household members (Table 6). The socio-economic indices were correlated with the level of cultivation of millets using pairwise Pearson correlations.

Table 4. Indicators used in construction of the income index

Variable	*Score*
Land Holding	0 – Less than 2 acres 5 – More than 2 and less than 5 acres 10 – More than 5 acres
Migrating family members to urban areas for additional income	0 – None 10 – 1 or more migrating members
Number of income earning occupations for the household	0 – Only agriculture 5 – Agriculture and agricultural labouring 10 – Occupation in addition to agriculture and agri-labour

Table 5. Indicators for the health index

Variable	*Score*
Premature death in the family in the past 5 years	0 – 1 or more 10 – None
Proximity to government healthcare facility	0 – More than 15km 5 – Between 5 and 15km 10 – Less than 5km
Number of family members on medication (or complaints of prolonged health problems)	0 – 1 or more 10 – None
Number of family members who are malnourished	0 – 1 or more 10 – None

Table 6. Indicators for the education index. The value is calculated for each of the family member, summed and divided by the total household size

Variable	*Score*
Grade completed in formal education	0 – No formal education 5 – till Grade 8th 10 – Grade 12th or more

Behaviour nudging

The second component of this study focused on evaluating the role of behavioural nudging in adoption of the POP. The farming practice we concentrated on for the purpose of this study was weeding the fields. Weeding is an effective means to increase productivity, yet it is something that farmers tend not to do for millets, as it takes a backseat to weeding the fields of paddy.

This small random control trial focused on six of the project villages, which were randomly selected from the set of 30 Project villages. One treatment and one control village were selected in each of the three focal blocks (Table 7). The selection of households within villages was randomized. Ten households per village were selected to receive the treatment or to serve as controls. The total sample size was 60, with an equal number of control and treatment samples. There were minimal chances for spill over from the treatment households to the control households as they were in different villages in a block.

Table 7. Treatment and control villages in each focal block for the behaviour nudging trials

Block	*Treatment village*	*Control village*
Mandla	Shivpuri	Tikraberpani
Mehandwani	Chanta	Kathotiya
Shahpura	Bhilai	Khursipar

Figure 3. The sticker which was used as a nudge to remind farmers to weed their millet fields

All of the sampled households were trained on the POP for millet cultivation during which they were told about the benefits of weeding and the role of millets in more resilient farming systems in the face of climate change. For the farmers in the treatment group, a sticker with a smiley face was provided at the time of the training to place on the door of their house as a behavioural 'nudge' (*sensu* Leonard 2008). They were told the sticker was to serve as a reminder for weeding their fields. Because much of the population in the study area had limited education and was not formally trained in reading, it was made sure that minimal writing was used on the stickers (Figure 3). It had pictures of millets and a smiley face. The smiley face was selected because it is a universal sign and an immediate association with positivity (Cools et al 2002). Similar smiley face stickers have been used in a study of water consumption in Costa Rica (Datta et al 2015).

Farmers' commitment to weed was documented at the time of training for both the control and treatment groups. In a later phase of data collection, the households were revisited and it was documented whether they had actually applied the weeding practice. A chi-square test was used to check if the treatment had a significant effect on adoption of the weeding practices for millet crops and a linear model was used to assess the effect of weeding on millet yield.

Results

Social factors linked to adoption

Millet cultivation and adoption of the POP

Households in Shahpura assigned the largest proportion of their land to millets (mean 39% of farmland), while households in Mandla assigned the smallest areas to millet cultivation (mean 15% of farmland) (Figure 4). Compliance with the POP was only seen in Mandla and by very few households. A mere 6.6% of households overall surveyed had adopted the recommended practices, corresponding to 20% of those surveyed in Mandla district (Table 8).

Table 8. Cultivation of millets and adoption rate of the POP in the three focal blocks

Block	*Overall*	*Mandla*	*Mehandwani*	*Shahpura*
Millets cultivated (% of households)	80	70	78	92
Kutki	60	65	47.5	67.5
Kodo	58	35	55	85
Mean % of land allocated to millets	25.5	15.4	23.1	37.9
Adoption of the POP (% of households)	6.7	20	0	0

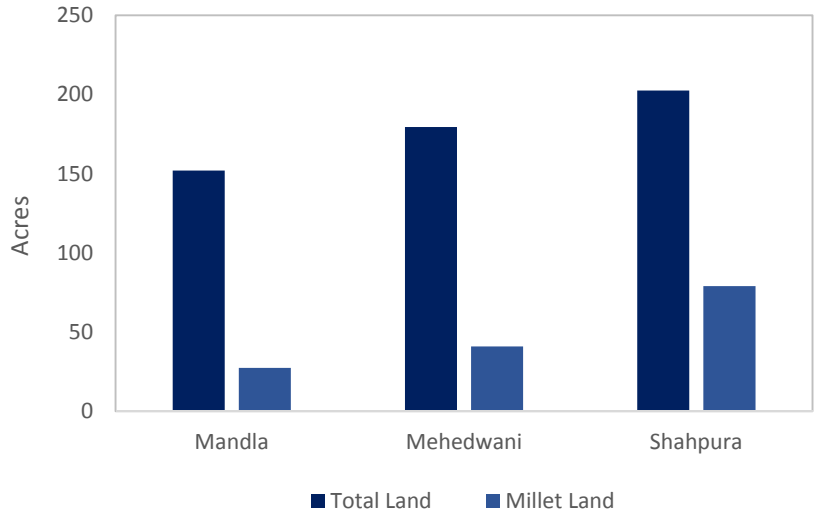

Figure 4. Total cultivated land and land under millet cultivation for the surveyed households in the three focal blocks of Madhya Pradesh

Correlations between cultivation of millets and socio-economic indices

The distributions of the index scores for income, health and education are shown in Figure 5. The mean scores for income, health, and education were fairly similar across the blocks (Table 9). Mehandwani had the highest mean scores for the health and education indices but the lowest mean score for the income index. Shahpura had the highest mean income score but the lowest mean score for the education index. Mandla had the lowest mean score for health.

Table 10 presents the pair-wise correlation of the index scores for income, health and education with the area under millet cultivation. All the correlations were weak, with none larger than 0.5 or smaller than -0.5. The income index had the strongest correlation with area under millet cultivation (Pearson's r=0.383), while the other factors were very weakly correlated. Due to the low sample size for adoption of the POP, statistical associations were not made for adoption with the socio-economic indicators.

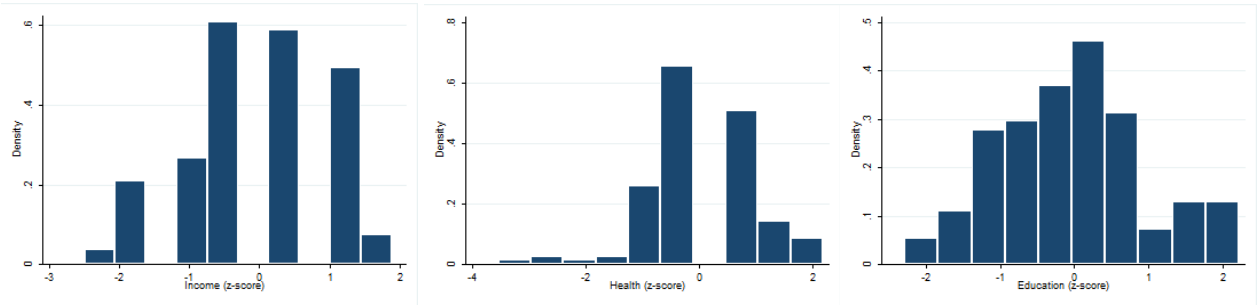

Figure 5. Density distribution of index components for income, health and education (left to right) calculated using z-score from a Principal Component Analysis (PCA) (Fukuda et al 2007; Krishnan 2010)

Table 9. Mean index scores for income, health, and education across the focal blocks

Block	*Mandla*	*Mehandwani*	*Shahpura*
Income Score	5.55	5.37	6.2
Health Score	5.56	7.35	7.06
Education Score	4.67	5.00	3.64

Table 10. Pairwise correlation between indices for income, education and health and area of millet cultivation

	Millet area	*Income Score*	*Health Score*	*Education Score*
Millet area	1			
Income Score	0.383	1		
Health Score	0.0167	-0.0375	1	
Education Score	-0.0931	0.0319	-0.0483	1

Behaviour nudging

While the training was being given to the farmers, a large percentage of the farmers committed to following the POP in both the treatment and control villages. However, in the end, when it was asked how many of them actually applied those practices, there was an obvious drop (Figure 6). For the households that received the smiley sticker, the dropout was nearly half that of the control households. The treatment group thus had significantly more adopters of the POP (Chi-Square = 6.9444, p=0.008; Table 11).

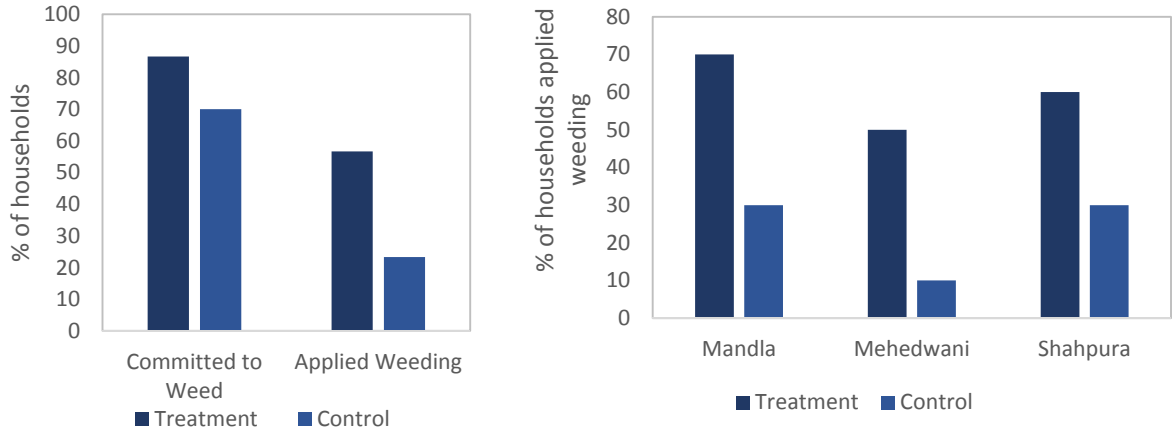

Figure 6. Adoption of weeding in the three blocks under study for those who received the sticker (treatment) and those who did not (control)

Table 11. Chi-square test of correlation for adoption of weeding by treatment group

	Control	*Treatment*	*Total*
Adopted Weeding	23	13	36
Did not adopt weeding	7	17	24
Total	30	30	60
Pearson's Chi-Square = 6.9444			
P-value = 0.008			

Table 13. General linear model explaining yield variation of kodo and kutki in different blocks depending whether farmers weeded their field or not

Estimate	*Std.*	*Error*	*t*	*value*	*Pr(>|t|)*
(Intercept)	163.16	23.94	6.815	8.01E-10	***
Block=Mehandwani	-96.48	28.59	-3.375	0.00106	**
Block=Shahpura	-91.95	29.57	-3.11	0.00246	**
Crop=Kodo	15.52	22.18	0.7	0.48572	
Weeding=Y	-27.07	35.69	-0.758	0.45008	
Crop=Kodo:Weeding=Y	-21.47	36.51	-0.588	0.55776	
Block=Mehandwani:Weeding=Y	87.2	46.55	1.873	0.06402	.
Block=Shahpura:Weeding=Y	53.69	45.4	1.183	0.23987	

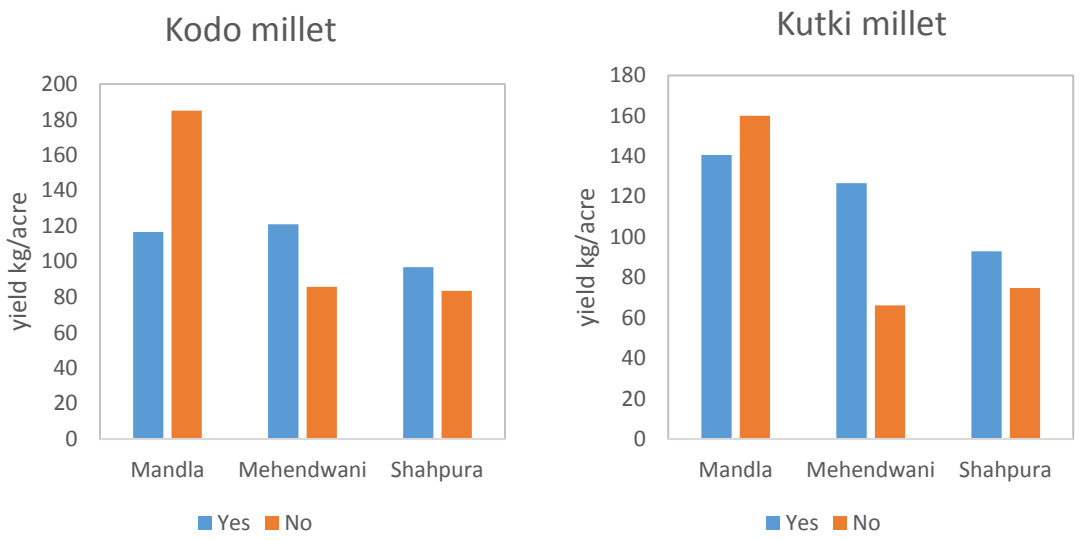

Figure 7. Reported yields of kodo and kutki in different blocks depending if farmers had weeded their fields or not

Weeding effect on yields

Yields achieved for millet were significantly lower in both blocks in Dindori district than in Mandla district (Table 12). Yields were slightly higher for kodo than for kutki overall, but the difference was not significant. Weeding did not result in significantly higher yields, although a trend in this direction was seen in Mehandwani block. A trend toward higher yields were seen for those who did not weed in Mandla block (Figure 7).

Discussion

Minor millets were grown by the majority of the households surveyed in the current investigation. There was a clear trend for higher cultivation of millets in Dindori district as compared to Mandla district. These results are generally in agreement with the baseline study, which revealed similar spatial trends in millet cultivation in the study area (Bioversity International and ASA 2017). The terrain in Dindori is steep and rocky so it is not possible to gain high yields of paddy and it is generally more suitable to millet cultivation. Mandla by contrast has flatter lands that are more suitable to paddy cultivation and much of the block has abandoned their traditional millets in favour of paddy with the development and promotion of rice technologies.

One hypothesis was that higher income earning households may be less inclined to cultivate millets because they may prefer to grow rice and because of the association of millets as a “poor man’s crop”. Instead the correlations revealed that households with a higher income index were in fact growing larger areas of millets. This correlation is explained by the fact that the income index was constructed considering primarily land area and sources of off-farm income. Farm sizes were largest in Dindori district but the land was steep and rocky, suitable only for cultivation of hardy crops like the millets. Farm sizes were smaller on

average in Mandla but the quality of the land was higher and more suitable for rice cultivation. Migration to seek labour positions was also more common in Dindori than in Mandla, which would have increased the income index for this region. Farmers in Mandla had fewer sources of off-farm income but they were more commercially-oriented in their farm production as seen in this study and the baseline study (Bioversity International and ASA 2017). Income from crop production was not well captured in the income index as the index considered only coarsely "income from agriculture", while farmers in the region tend to consider subsistence production as a form of income (Bioversity International and ASA 2017).

Further work on tuning the indices is needed to improve their utility, including testing them against direct measures of income, education, and health. One factor related to income that was not captured in the current index was renting lands. There were several families that were renting lands to smaller farmers and in return were given half of the production of their crops. A similar practice was also seen for seeds, where individuals lent seed to farmers on the promise that they would return 1.5 or 2 times the volume at harvest. These are factors that would affect the income of households and should be considered for improving the income index. The education and health indices were not strongly related to the cultivation of millets and could be sharpened by revisiting the scoring system and including other relevant variables. The major health concerns in the area were back pain, pain in the limbs, skin problems, urinary problems, cold fever, and digestion problems. Women hesitatingly revealed problems of reproductive tract infection. In addition to these issues there was also a problem with general weakness in the body. Because of lack of health facilities close to many of the villages it was not possible for the people to have their symptoms diagnosed. There are many superstitions around health in the region and often people prefer going to an exorcist than a doctor. The availability of medicines is through private, untrained vendors who sell them at a great profit margin. In terms of education, it was observed that there were problems of teacher absenteeism and school buildings being used for storage in the study region. It was also noted that with the lack of electricity in the study region, students were not able to study at home. According to the Right to Education Act, any student cannot be held back in any grade up until the 8th grade. Because of this law and other benefits of schooling, such as mid-day meals and school uniforms, most people continue their education until this level but then drop out to work on their farms and take on labour positions. These are observations that can support development of the indices for future studies.

In contrast to results for cultivation, the highest rate of adoption for the promoted POP was in Mandla. This was the only block out of the three where some farmers were documented to be using the line sowing method for millets. Most farmers in Mandla still chose to broadcast seeds but some were trying the POP they learned in their self-help groups. In Dindori, farmers were more reluctant to adopt the POP. These farmers seem to have a lower capacity for risk-taking as they are highly dependent on their fragile production from marginal lands. They were concerned they may not have enough to eat should they suffer a crop failure. While they did not adopt the POP it was notable in this region that there was a greater sense of caring for the millet crops. Several farmers had protection mechanisms in place to save the crops from being eaten by animals and they dedicated time to properly weeding their millet fields following their traditional practices. In Mandla instead, where millets were falling out of production, the farmers were not generally putting effort into weeding or maintaining the field where they grow minor millets.

The behavioural 'nudge' in the form of a smiling sticker was seen to encourage adoption of the weeding practice for millets. Although the sample for this experiment was fairly small, it showed remarkably significant results. A high percentage of households agreed to weed their fields at the time of the training

however it did not culminate into reality for many, showing a prevalence of hyperbolic discounting on the part of the farmers (Frederik et al 2002). A study by Banik and colleagues (2006) similarly showed farmers to ignore weeding despite its demonstrated benefits. The reminder sticker had a significantly positive effect on adoption of weeding in accordance with other studies that have shown positive effects of personal reminders (Karlan et al 2016, Datta et al 2015). The farmers mentioned they would often look at the stickers and remember the particular session where they were given the instructions for the POP but they did not necessarily think about the sticker while they were taking care of their fields.

The compilation of the best practices for these millets in still process. Although line sowing is the most scientific method for maximum output it was observed that the lightweight seeds were often washed down the hill sides by early rains. In addition, if the seed was planted too low in the soil, it failed to sprout at all. Nevertheless, simply broadcasting the seeds, as it has been done by the farmers in the region, results in lower yields than their potential and increases the burden of weeding. Suggestions by the farmers to improve the POP included broadcasting seed followed by thinning and gap filling rather than line sowing, which would be more suitable for the sloping lands where they tend to plant millets.

Conclusions

In the past years there has been a shift in agricultural patterns in eastern Madhya Pradesh. Much of the region has turned toward growing paddy instead of minor millets. This trend, seen most strongly in Mandla district, has caused a loss of biodiversity in the region and leaves the farming systems more fragile in facing the challenges of climate change. In Dindori, millets are still very commonly grown but they have low yields due to inefficient production practices. Agricultural technology such as SRI and SWI have substantially helped the growth in supply of these grains and similar effects could be seen with promotion of improved technologies for millets. Improved cultivation practices for millets in Madhya Pradesh have been developed by the KVK and are being promoted in the Project area by teaching the practices to local self-help groups.

This study explored some socioeconomic and psychological factors related to adoption of millet cultivation and improved cultivation practices for millets. The analysis highlighted factors linked to higher millet cultivation in Dindori district, where farmers have larger but more marginal landholdings and higher rates of migration for paid labour as compared to farmers in Mandla district. In Mandla, landholdings are smaller but the terrain is more suitable to rice cultivation, which has enabled the abandonment of traditional millets. While millet cultivation was more common in Dindori, farmers in this region were more hesitant to adopt the POP because of their high risk aversion.

Some possible improvements to the POP were suggested by the farmers in this study which could be explored and tested in the Project to improve farmer adoption. In particular, line sowing was not working well in the steep terrains cultivated by farmers in the study area. Mechanical implements to facilitate the sowing process could be explored. A personal reminder in the form of a sticker was seen to encourage farmers to implement the best practices for millet cultivation. These lessons can be taken forward as the Project continues to research and promote minor millets to build resilience of these agricultural systems and farmers' livelihoods to climate change

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