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Understanding farmers' cropping decisions and implications for crop diversity conservation: Insights from Central India

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A B S T R A C T

Conserving crop diversity is promoted for global food system stability and creating local benefits like improved farmer nutrition, incomes and adaptive capacities. However, little is known about how farmers make decisions shaping crop diversity, and how conservation efforts can be aligned with farmers' goals. This study examines how interacting values, rules and knowledge shape decisions of subsistence farmers in central India. Findings suggest that farmers' values play a central role in shaping crop diversity. Their culinary and health preferences for consuming various self-cultivated crops primarily drive portfolio decisions. Farmers are hesitant to invest in commercial agricultural because of unreliable returns. Furthermore, they prefer to control water availability and land quality as means of coping with environmental change, rather than resorting to crop diversification. Finally, a rich understanding of local crop diversity dynamics questions the ethics of expecting marginal farmers to shoulder the burden of conservation for global gain, suggesting ex-situ strategies are appropriate where in-situ practices are not autonomously selected. Overall, the analysis demonstrates the importance of understanding farmer-level decision-making for wider crop diversity conservation debates.

1. Introduction

Crop diversity[3] is essential for sustained agricultural yields and food security, and is a vital component of biodiversity (Thrupp, 2000). Researchers and practitioners are keen on encouraging smallholder farmers to retain the crop diversity they have cultivated over generations (Convention on Biological Diversity, 2019; Jarvis et al., 2016). Along with creating global benefits, crop diversity can also contribute to farmers' nutrition, adaptive capacities and incomes (Altieri et al., 2015; Jones et al., 2014; Lin, 2011; Meldrum et al., 2017; Mofya-Mukuka and Hichaambwa, 2018; Pellegrini and Tasciotti, 2014; Pudasaini et al., 2013; Sthapit et al., 2010). However, the conditions under which crop diversity conservation can truly accrue these benefits to farmers are unclear. There are also unresolved debates on whether crop diversity has increased or decreased at local levels, and if it should be conserved through in-situ practices or ex-situ means. Addressing these questions is critical for designing appropriate conservation measures that can benefit targeted communities.

At the global scale, the paradigm of crop diversity conservation has been driven by concerns of agricultural simplification and the overall instability of global food supplies (Khoury et al., 2014; Padulosi et al., 2001). Climate change has amplified the importance of crop diversity conservation since genetic diversity is essential to ensuring food security under changing agro-climatic conditions (Esquinas-Alcázar, 2005; FAO, 2015; Khoury et al., 2014).

In addition to being essential for the stability of the global food

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[3] 'Agrobiodiversity refers to the variety and variability of living organisms that contribute to food and agriculture in the broadest sense' (Montenegro de Wit, 2015). Within the large category of agricultural biodiversity, the focus of this study is on cultivated crop diversity (hereon referred to as crop diversity), described by Engels et al. (2014) as 'plant genetic resources for food and agriculture (PGRFA), the diversity within and among crops, their wild relatives and wild edible plant species.'

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system, crop diversity conservation at the local scale,[4] through maintaining crop portfolios (the set of crop species and varieties cultivated by a single farmer) with multiple species and varieties of crops, can also accrue benefits to farmers. Diversity-based risk management strategies have been traditionally employed by agricultural communities, and are recommended for climate resilience and stable harvests (e.g. Altieri et al., 2015; Clawson, 1985; Lin, 2011; Meldrum et al., 2017; PAR, 2009; Sthapit et al., 2010). Since smallholder farmers are regularly subsistence cultivators, a common perception is that maintaining a diversity of crops for household consumption could also be a feasible solution for undernutrition and malnutrition (Jones et al., 2014; Pellegrini and Tasciotti, 2014; Pudasaini et al., 2013; Sharma, 2004; Sibhatu et al., 2015). Crop diversification also holds economic promise. While monocultures remain the most common production system due to habit, simplicity, and real and perceived profitability (Klasen et al., 2016), there is growing recognition that they are sub-optimal in terms of ecological outcomes and medium- to long-term financial perspectives (Foley et al., 2005; Nambiar, 1994; Wood et al., 2000). Diversification can increase yields under heterogenous agro-ecological conditions and maximise utility (Bellon and Taylor, 1993; Mofya-Mukuka and Hichaambwa, 2018). The extent to which diversity-rich crop portfolios can create such benefits at the local level is, however, context-dependent (Aweke et al., 2020; Jarvis et al., 2011; Muthini et al., 2020).

An important debate in the literature around crop diversity is centred around whether it has increased or decreased at local levels, and the suitable strategy for its conservation. One group of researchers has observed a reduction in crop diversity through agricultural homogenisation, the loss of local varieties and interrupted native varietal evolution (Khoury et al., 2014; Thrupp, 2000; Wilkes, 1994). This view advocates for ex-situ conservation to preserve the genetic material of supplanted crops. A contrasting perspective reports diversity to be stable or have increased, contending that the acceptance of commercial varieties by marginal farmers worldwide has led to increased species richness rather than diminishing it (Brush, 1991; Jarvis et al., 2011). This position supports in-situ conservation as a method that allows selective breeding to continue, conserves cultural know-how along with crop varieties, and is more affordable. Montenegro de Wit (2015) suggests that this debate may have arisen because of different scales of assessment; while there *has* been crop diversity erosion globally, at the local scale, the change in diversity is context-dependent. Given that there are such contrasting perspectives on crop diversity dynamics at local levels, there is a need to evaluate at the level of farmers, the decision-making process that dictates either persistence or loss of diversity. This is important, not only because it has implications for the conservation paradigm, but because decisions around crop repertoires impact most immediately the decision-makers, the farmers, themselves. Imposing conservation regimes for global gain without understanding farmers' motivations and decision-making is ultimately unjust (Martin et al., 2013; Vincent, 1998).

Past studies on crop portfolio and agricultural technology selection do analyse the process of farmer-level decision-making. However, some analyses overlook complexity by adopting simplistic assumptions and neglecting important factors. For example, much of the work in agricultural economics and agronomics assumes decision-making to be aimed at efficiently using resources to maximise profit (Babcock and Hennessy, 1996; Bellon and Taylor, 1993; Gómez-Limón et al., 2004; Oglethorpe, 1995; Robert et al., 2016). However, agricultural decisions can be driven by goals other than economic efficiency, and cultural values like culinary, aesthetic and nutritional appeal also influence portfolios (Brush, 1991; Zimmerer, 2014, 1991). Even outside economic methods, model-based approaches within social sciences (Below et al., 2012; Deressa et al., 2009) often reduce decision-making to an algorithmic routine dictated by bio-physical and socio-economic constraints. While agricultural decisions *are* shaped by systemic influences like land fertility, poverty and climate variability, farmers also have agency over the social-ecological systems within which they operate. Zooming out of decision models, literature in disciplines like political ecology, biocultural studies, ethnobiology and cultural ecology recognises the influence of human values and agency on nature, farming systems and agricultural portfolios, and on crop diversity conservation. While some authors have recognised the role of nature in directing the development of culture (Khan, 2013; Montenegro de Wit, 2015), others (Jarvis and Hodgkin, 1999; Lacy, 1994; Plieninger and Bieling, 2012; Robbins, 2004) have observed 'cultural beliefs and practices guiding ecosystem management' (Comberti et al., 2015, p. 253), closing the loop of nature-culture interactions.

Evidently, understanding farmers' decisions requires a holistic framework which recognises that decision-making is a complex, context-specific process with interdependent 'extrinsic' factors (like environmental conditions and farmer income-level) and intrinsic variables ('knowledge, perceptions and attitudes') (Meijer et al., 2015, p. 44). The following section draws on a framework advanced by Gorddard et al. (2016) to synthesise these factors which have previously been considered disparately.

1.1. Understanding farmers' decision-making: Values-rules-knowledge

This paper draws on and adapts the value-rules-knowledge (vrk) framework proposed by Gorddard et al. (2016) to examine farmers' decision-making. Under this understanding, decisions are rooted in a 'decision context', produced through the interactions of three interdependent variables – values, rules and knowledge. Although this framework was developed in the adaptation context, the broad framing can, with some clarifications outlined below, be usefully adopted for analysing agricultural decision-making. This study contextualises the framework to agricultural settings and conceptualises the three core dimensions as follows.

Values represent farmers' aspirations and preferences, which could be related to taste, monetary potential, visual aesthetic, heritage, etc. For instance, Zimmerer [1991, p. 43] studying potato and maize diversity in Quechua communities observes decisions to follow from 'culinary, commercial and household-economic objectives'. Values are analogous to Sinha et al.'s (1988, p. 93) conception of 'fuzzy goals', or 'imprecise aspirations' of stakeholders. Crops are valued 'within a larger economy of signification which crucially shapes their modes of appropriation. They are also resources for collective representation that exceed the concern with immediate material use' (Baviskar, 2003, p. 5052). Further, values are not binding constraints, but they guide decisions, especially when 'rules' (explained below) do not lead to a single solution.

While Gorddard et al. (2016, p. 62) conceptualised rules as 'norms, practices, taboos, habits, heuristics (rules-in-use) and regulations, legislation, treaties and ordinances (rules-in-form)', this study views rules as also composing of wider 'system constraints' (after Sinha et al., 1988). Crucially, this encompasses 'biophysical constraints' (Soleri and Cleveland, 1993) such as limited water, land, and nutrients (Turner, 2016) as well as other limitations like the availability of seeds and labour. This still follows conceptually from Gorddard et al.' s (2017) idea of rules as factors that 'enable implementation', but recognises that at

[4] This study defines crop diversity at the local or community scale as the diversity of crop species growing at the same time on a field (measured as species richness (Jarvis et al., 2008)) and genetic diversity created by the cultivation of different varieties in a monoculture or polyculture (Lin, 2011) (measured as varieties richness (Jarvis et al., 2008)). Evenness, referring to the relative frequencies of different species or different varieties cultivated on the same field, and divergence, the diversity of crop and variety mixes planted on different fields in the same village are also included (Jarvis et al., 2008). Further, 'temporal diversity created through crop rotations' (Lin, 2011, p. 185), and diversity preserved by farmers through saving seeds of different crops and varieties (Engels et al., 2014) are also considered elements of crop diversity.

the level of the farmer, the absence of certain material resources can be equally or more constraining than institutional or societal arrangements. Therefore, policies and institutions, although acknowledged as integral to the provisioning of resources and infrastructure, are not the primary focus of this analysis. Although this is a limitation of the study, it is, as outlined in the results, advantageous in illustrating the aspirational shift in crop choice in the study area, which might have remained hidden in enquiry focussing on policy drivers. Further, since the selected community is relatively insulated from market forces as it practises subsistence agriculture, the exclusion of these factors is not a significant omission here.

Knowledge, here, refers to the 'evidence, beliefs and judgments about how the social-ecological system works, an understanding of future changes and the consequences of different decisions' (van Kerkhoff, 2017). Farmers draw on different kinds of knowledge when making decisions. For instance, Bellon and Taylor (1993, p. 769) observe that indigenous farmers in Chiapas employ an understanding of 'varietal response to ecological conditions (drought, wind, weeds, performance with intercropping), technological requirements (input intensity, timing of cultural practices), and yield and use (aptness for subsistence or market, storage properties, taste).' Indigenous smallholder farmers draw on knowledge that is constantly evolving, integrating 'traditional ecological knowledge', with information on modern developments and technology (Escobar, 1998; Gómez-Baggethun et al., 2013). Also, individuals may internalise information in their own ways, which may lead to the production of knowledge different from that of other people, communities, institutions or Western science (Dove, 2003).

This paper uses the vrk framework to explore agricultural decision-making among farmers of the indigenous Gond community in Dungariya Forest Village in central India. This community traditionally cultivates several species and varieties of crops, and has also experienced cropping, environmental, cultural and culinary changes, a situation that applies to several agricultural communities in India and the rest of the world (Bisht et al., 2020; Dweba and Mearns, 2011; Food and Agriculture Organization of the United Nations, 2017; Lacy, 1994; Zhang et al., 2017). Exploring crop diversity conservation in an indigenous community also makes sense given the global thrust on biodiversity conservation in indigenous lands, supported by findings around indigenous peoples occupying a quarter of the global land territory and safeguarding around 80% of the global biodiversity (FAO, 2017; Garnett et al., 2018).

The study assesses the ongoing crop diversity changes in Dungariya and analyses how farmers make crop portfolio decisions, specifically about the diversity of crops they cultivate. It also analyses farmers' perceptions around the linkages of crop diversity with nutrition, household incomes and environmental change adaptation. The findings finally lead to a discussion on the implications of farmers' decision-making on debates regarding the appropriate strategy for effective conservation of crop diversity.[5]

2. Methodology

2.1. Study area

The study is situated in Dungariya Forest Village (Dungariya), in Mandla District of Madhya Pradesh state in central India. Poverty and nutrition insecurity are prevalent in Mandla (Bioversity International and Action for Social Advancement, 2016; International Institute for Population Sciences, 2017) and agriculture is highly climate vulnerable (Gosain et al., 2017).

Mandla has a tropical climate with extreme summers (mean daily maximum temperature in summer is 47.7 °C) and moderate winters (Ministry of Water Resources, 2013). It receives an average annual rainfall of 1048 mm, mainly between June and September. Dungariya is located 20 km from the district headquarters and is accessible by an all-weather road. A central road runs through the village with houses on either side, followed by fields and surrounded by forest (See Figs. 1 and 2).

The population according to the most recent census was 284 (138 male and 146 female), in 60 households (Directorate of Census Operations, Madhya Pradesh, 2011). Households belong to the Gond tribe, a Scheduled Tribe community which has been historically prevalent in central India (Kala, 2013) and is one of the largest in terms of population and geographical spread (Mukherjee et al., 2000). Livelihoods mainly consist of marginal and small-scale farming, forest produce collection and labour work. All interviewed households have at least two members farming full-time and no labour is hired. Young men increasingly supplement incomes with employment outside agriculture. (See Table 1 for basic demographic data on Dungariya from the Census of India and Table 2 for population composition data for the Mandla district from the Census of India.)

Landholdings in the community vary between 2 and 6 acres per household. Farmers describe their fields as having either red (*barra)*, yellow or black soil, levelled or undulating ground, and being bunded or un-bunded. Until recently, agriculture was rainfed, but with the digging of wells, farmers are increasingly able to irrigate outside the monsoon. The community cultivates cereals, grain legumes and oil seeds in two main growing seasons, *kharif* (monsoon, July–October) and *rabi* (winter, November–February) (Appendix B). Based on seasonality in crop growth and land variability, the community has established an annual rainfed cropping system (Appendix C). In the *kharif* season, farmers plant and flood-irrigate paddy in level and bunded fields. In home gardens, they cultivate maize with other crops like vegetables, pulses (pigeon pea and black gram) and oilseeds (niger), using mixed-cropping based on pre-formed groups. Millets are grown in *barra* (sloping land near the forest having coarse red soil). In the *rabi* season, winter vegetables like cauliflower, spinach and fenugreek are planted along with wheat, *batra*, *masoor* and chickpea. Farmers with wells also take a third crop in *zaid* (summer, March–June).

All households are self-sufficient for paddy (rice), maize and various grain legumes (pulses). Most households purchase vegetables from the market since they only grow some during the monsoon. Villagers farm principally for subsistence, selling only extra produce, or when they need money in times of emergency. The subsistence orientation of agriculture in Dungariya makes it relatively insulated from market forces and wider agricultural policy factors (like subsidies and procurement) which could influence cropping decisions.

2.2. Methods

2.2.1. Interviews

Key informant interviews ($n = 7$) were conducted with locally active NGOs (Bioversity International and Action for Social Advancement (ASA)) and government agricultural institutions to prepare for fieldwork. These semi-structured interviews included a discussion on the nature of involvement of the interviewee or their organization with the community in Dungariya and their understanding of the crop selection and agricultural practices followed by the community.

Semi-structured interviews with community members were conducted in June 2017 in the local language (Hindi). Each interview was

[5] The scope of this analysis is restricted to analysing the crop diversity implications of farmers' current decisions. While topics like future cropping changes, their environmental impacts or their monetary ramifications for farmers are interesting and important issues, they remain outside the scope of this study and may be probed in further research.

Fig. 1. Google Maps images of Dungariya.

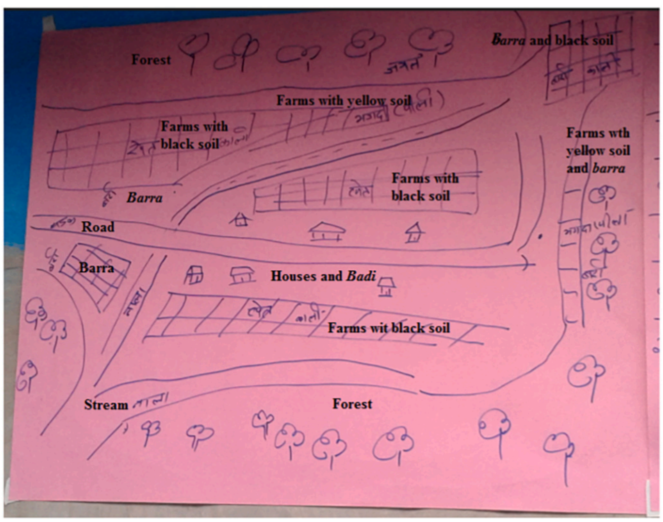

Fig. 2. Map created through participatory mapping as part of the diversification exercise.

Table 1
Demographic data for Dungariya village from the Census of India (2011).

	Total	Male	Female
No. of households	60	–	–
Population	284	138	146
Literacy rate (%)	57.04	70.29	44.52
Total land area (ha)	209	–	–
Average landholding size (ha)	0.73	–	–

Table 2
Relevant population composition data for Mandla district from Census of India (2011).

Proportion of rural population to total population	87.7
Proportion of Scheduled Castes to total population	4.6
Proportion of Scheduled Tribes to total population	57.9

40–50 min long, and included questions around land and water availability, crops and varieties[6] cultivated, preferred strategies (including crop diversification) for nutrition security, income stability and environmental adaptation, and agricultural and culinary aspirations. Respondents from 24 households were interviewed (11 men and 13 women), covering over a third of the total number of households. Random selection was performed for the first four interviews, followed by snowball sampling. The village elder was specifically interviewed about the agricultural history of the village and the Gond peoples.

Interviews were translated and transcribed, and responses were coded using NVivo, to segregate them into categories of 'values', 'rules' and 'knowledge'. Within each category, sub-groups were observed to be forming naturally. Coding based on these sub-groups was continued, with new sub-groups created when new responses were observed, and the previous interviews revisited to include relevant content from them. The frequency and significance accorded to each issue was taken into account during analysis. While frequency was measured by counting the number of interviewees who had mentioned an issue, assessing the significance was a slightly more subjective process. The spontaneity of a response and the length at which the respondent spoke about an issue compared to others he/she mentioned were considered yardsticks of its significance to that interviewee.

Semi-structured interviews were preferred because although they tend to be longer than structured interviews, their free-flowing nature allows interesting points to be probed further. Bernard (1995) recommends this method of interviewing for situations where the researcher has only one chance to interview a respondent. This was a working constraint, since the study did not want to take up too much of the villagers' time, making this style of interviewing all the more suitable.

Informal interaction, participant observation and activities like visiting the local market, and cooking and eating with the villagers during fieldwork helped triangulate data.

2.2.2. *Participatory exercises*

Two kinds of participatory exercises were conducted in focus groups of 10–14 participants each on separate days.

2.2.2.1. Four-cell analysis (FCA). It was apparent from the interviews that certain crops and varieties were more commonly cultivated than others. However, deriving details around the actual composition of cereal and legume portfolios (the area allocated to each variety) was not possible from individual interviews. An FCA was thus conducted with the goal of gaining clarity on species and variety richness (the number of

[6] The study used named varieties to understand diversity perceived by the community without imposing Western scientific characterisation on local 'epistemologies of recognition' (Montenegro de Wit, 2015).

species and varieties), evenness (the relative frequencies of different crops in one field; low evenness indicates the dominance of the cropped area by one or a few species or varieties) and divergence (‘the proportion of community evenness displayed between farms or households … High divergence implies the community is maintaining genetic diversity among farms’ (Jarvis et al., 2008, p. 5330)) in Dungariya. The FCA also helped uncover differences between the current and ‘traditional’ crop mix.

All cereal and legume crops and varieties identified from the diversification exercise (described below) were used. Variety names were written on individual slips of paper and placed into separate *kharif* (monsoon) and *rabi* (winter) piles. Each slip was read out, there was a discussion about the number of households (many/few) and area of land over which the crop was cultivated (small/large) and the slip was placed in a quadrant (many-large, many-small, few-large or few-small) corresponding to the consensus opinion. Participants determined the thresholds between ‘many’ and ‘few’ farmers, and ‘large’ and ‘small’ area.

2.2.2.2. Diversification exercise. A participatory exercise was designed by Bioversity International to understand farmers' perceptions of environmental change, and their adaptation knowledge and preferences (Mijatović et al., 2019). This exercise consists of participatory preparations of a village map, an extreme-weather events timeline and tables describing the annual crop calendar, identifying observed recent weather changes and listing available agricultural coping strategies. We conducted the exercise during fieldwork and analysed relevant data from it. In particular, the participatory village map (Fig. 2) was useful to understand the distribution of agricultural land and variability in its characteristics, and the annual crop calendar helped understand farmers' experiences of environmental change and preferred adaptation strategies.

3. Results

This section describes the crop diversity dynamics in Dungariya and explores the process of farmers' decision-making that lead to these changes. It then analyses farmers' perceptions on the relationship between crop diversification and nutrition, environmental change adaptation and improved incomes. This analysis paves the way for a discussion on suitable crop diversity conservation strategies in the next section. Quotes from interviews are accompanied by information on the respondents' gender and age, in the format (gender, age).

3.1. Crop diversity dynamics in Dungariya

The community previously cultivated few vegetables and different

Kharif (Monsoon crops)

Many households, small area	Many households, large area
Millet: *Safed kutki**, *Kali kutki** Pulses: *Khasari urad** (black gram), *Khutiya urad** (black gram)	Paddy: MTU 10-10† Maize: *Peela* (yellow)†, *Dudhmagari** (white) Pulses: *Mahiya rahar** (pigeon pea)
Few households, small area	**Few households, large area**
Paddy: *Jholar**, *Lochai**, *Chindi kapoor**, *Kardhana** Millet: *Chhoti kodo**, *Badi kodo**, *Rakhi kodo**, *Unnat kodo**, *Chhota sama**, *Bhadeli kutki** Pulses: *Semidal**, *Sabzi rahar** (pigeon pea), *Batri**	

No households
Paddy: *Chhoti nunangi**, *Oraiboota**, *Badi nunagi**, *Kranti*
Millet: *Safed kangani**, *Lal kangani**, *Kali kangani**, *Jowar**, *Bajra**, *Mudhiya sama**
Pulses: *Chaitaha rahar** (pigeon pea), *Beliya urad** (black gram)

Rabi (Winter) Crops

Many households, small area	Many households, large area
Wheat: WH† Pulses: *Jhumaki batara**, Chickpea*	Wheat: *Sujata*† Pulses: *Masoor**
Few households, small area	**Few households, large area**
Pulses: *Phalli batra**, *Kali batra**, *Masara**, *Lakhodi**	

No households
Wheat: *Narmadaachaar**, *Mangala**
Pulses: *Larangha** (grows on all farms but no longer harvested)

Fig. 3. Results of the four-cell analysis for cereals, pulses and oilseeds. Local names (italicised) have been used to identify varieties. Names marked with an asterisk (*) and dagger (†) were confirmed to be native and newly introduced varieties respectively.

species and varieties of cereals, pulses and oilseeds to optimise for variable growing conditions and water scarcity (Appendices B and C). With access to new crop and variety seeds and increased ability to irrigate, farmers now cultivate a greater land area and a wider range of crops. Semi-structured interviews revealed a transition of vegetable diversity towards high species richness and evenness, since, with increased irrigation, several vegetables are now cultivated in small quantities throughout the year for domestic consumption. Some new paddy, maize and wheat varieties have also been added to the previous crop mix (Fig. 3), increasing the total diversity of crops at the level of the village.

At the same time, there is a gradual loss in traditional diversity, particularly for cereals and pulses. In the FCA (Fig. 3), several varieties were recorded as being cultivated by 'few households in small areas' or by 'no households', indicating that old varieties are slowly being lost from the local gene pool. For instance, all farmers plant the 'MTU 10–10' paddy variety over large areas, while other paddy varieties are cultivated by few farmers over smaller areas. Overall, for cereals and pulses, there appears to be low varietal richness and evenness on individual fields, but relatively high divergence (different farms cultivate different native varieties), along with a loss of native varieties.

Overall, Dungariya has seen an erosion in traditional diversity along with an increase in the total diversity of crops being cultivated. The role of farmers' decision-making in this process is described below.

3.2. How do farmers make decisions about the diversity in their crop portfolio?

Table 3 lists our findings on farmers' cropping decisions by crop types. We find that several different values, system constraints and types of knowledge influence crop choices. Values include culinary diversity, taste of produce, aesthetic preferences around farms, wariness around chemicals used in commercial produce, and aspiration to cultivate and consume modern paddy varieties. These values are influenced by farmers' knowledge, and also enable them to alter system constraints to cultivate their preferred crops.

Table 3
A summary of the relevant values, system constraints and knowledge that shape three key decisions related to diversity; vegetable diversity, paddy (rice) diversity and paddy vs. millets.

Crop portfolio decision	Values	System constraints	Knowledge
Vegetable diversity	Culinary diversity Taste of vegetables Aesthetic of vegetable patches Wary of chemical use in commercial produce Increasing household income Income stability	Irrigation Land availability Labour Volatile market prices	Planting techniques Chemical use in commercial produce Market prices and their volatility
Paddy diversity	Culinary diversity Taste (flavour and texture) Visual aesthetic (food and crop) Increasing household income Income stability	Land slope Soil quality Bunding Rainfall Irrigation Volatile market prices	Growing conditions for different varieties Water-holding capacities of different fields Market prices and their volatility
Paddy vs. millets decisions	Aspiration to cultivate and consume rice Taste Aesthetic of farms Increasing household income Income stability	Land undulation Bunding Hard work in planting, weeding and processing millets Mammal pests (lack of fencing) Volatile market prices	Nutrition Agricultural know-how Market prices and their volatility

Culinary diversity appears to be the strongest determinant of crop choice; when asked 'Why is it important to cultivate a diversity of crops?' the most common (75%; $n = 24$) answer was, 'because we like to eat a variety of food'. (The second most common (33%; n = 24) answer was 'because we can earn more money'; economic motivations behind crop choice are discussed below.) As one farmer explained, 'With one acre of land, someone would naturally think of growing at least three types of crops in every season so that they could eat different things' (female, 29). This situation is particularly prominent for vegetable portfolios, 'For the past 2-3 years we are growing many more vegetables and green leafy vegetables. This is because we have a well. It's nice to grow so many vegetables. Mainly to eat, but we can also sell them in times of hardship or if we have a good harvest' (female, 50). The farmers' appreciation of culinary diversity is also visible in paddy portfolios. While they segregate varieties into two categories based on water requirement, they traditionally cultivate multiple varieties within each group because they enjoy diversity in taste. This value of high culinary diversity operates to increase varietal richness.

Along with culinary inclinations, aesthetic preferences also inform decisions. For example, there is an appreciation of 'green vegetable patches'. As one respondent explained: 'Some farmers have started growing lots of vegetables. They grow papaya, cauliflower, potato, green vegetables. The farms are very *hara-bhara* (green) and nice to look at' (female, 23). As well as increasing diversity, aesthetic considerations can also lead to a localised evenness, as in the case of paddies, where a visual aesthetic of uniform green paddy fields in the village is valued. When asked which farmers have the best land, farmers maintaining large homogenous stands of paddy, rather than a patchwork of different-looking stands, were regularly identified.

In addition to aesthetics driving diversity in different directions, an aspirational value associated with rice has driven the transition in cereal staple away from millets in Dungariya. Respondents mention that brides from affluent families in other villages would only eat rice. As children were brought up on rice, they became accustomed to its taste and refuse to eat millets, another often-cited reason for choosing paddy over millets. There has also been a shift towards thinner- and longer-grained paddy varieties, and some coarse-grained varieties have been discontinued. This has also contributed to a loss in traditional diversity.

Farmers currently grow cereals mainly for personal consumption, selling only what remains from good harvests. Although some respondents noted that millets (particularly little millet) seem to have a good market price, they haven't really started cultivating them. This further suggests that at present, culinary value seems to the decision-driver, rather than market forces like the preferential procurement of certain crops by private buyers or the government (through the Minimum Support Price and for the Public Distribution System).

The farmers' cropping decisions are also determined by agricultural know-how. Their knowledge of system constraints on land availability and undulation, soil type, precipitation distribution, irrigation availability, planting techniques and growing requirements of crops, labour requirement and presence of pests ultimately determines their decisions and practices.

Increasingly, farmers are able to shape the system constraints according to their values and in line with key knowledge. For example, while farmers previously had to optimise for variable rainfall by growing both low- and high-water requiring paddy varieties, they are increasingly able to irrigate and retain water by digging wells, and levelling and bunding fields. These investments cater to the visual aesthetic of uniform fields and allow the cultivation of paddy varieties requiring more water. As one farmer explained: 'Earlier, we used to have to grow mainly *halka* [low-water requirement] varieties, but now, we have improved our land and have irrigation facility, and are able to grow more *gahrun* [high-water requirement] varieties despite rain being increasingly erratic,' (male, 45). When asked about who in the village had the 'best' farm, the most common answer was, "farmers who have been able to 'improve' their land have the best farms". The usage of the term 'improved' for level and bunded land with black or yellow soil, which can hold water for wet-rice cultivation, indicates the value of paddy and that farmers are willing to invest in changing previously constraining biophysical rules to cultivate preferred varieties. Similarly, the gradual relaxation of water constraints helps to expand vegetable cultivation. Since food grains take precedence under limited water, rainfed lands only cultivate vegetables during the monsoon. With the digging of wells, some farmers have started planting many vegetables year-round. However, labour remains a limiting factor, because vegetables need additional effort to plant, weed and harvest.

Given time and labour constraints, villagers find it easier to weed, harvest and process paddy than labour-intensive millets. Millet fields on coarse soil near the forest edge are also often attacked by mammal pests like cattle and wild pigs.

In addition to having pre-existing agricultural know-how, farmers are making efforts to gain knowledge about cultivation practices from one another and from workshops conducted by ASA, since they value growing different vegetables and can foresee a reduction in the constraining factor ('rule') of limited irrigation.

Farmers' acquired knowledge also shapes their values. The villagers seem averse to purchasing vegetables and keen on cultivating what they want to eat. Knowledge about chemicals in commercially cultivated produce has been crucial in forming this value. As one farmer explained, 'You won't believe what the chemicals do, I have seen this in my in-laws' village. If you spray the plant in the evening, it will flower overnight and fruit by morning. This is done for everything, beans, bottle gourd, bitter gourd. This is all English medicine. Now if they are growing so fast, won't they be harmful for the body? But we have to buy them out of necessity. If we had irrigation arrangements, we would grow them ourselves' (male, 35).

In summary, the community's cropping decisions are primarily driven by their preferences for consuming a diverse mix of self-cultivated produce, and supported by their agricultural knowledge and increasing ability to irrigate, which previously constrained the variety in their crop portfolios.

3.3. How are cropping decisions related to nutrition, incomes, and climate adaptation?

3.3.1. Nutrition

Table 4 illustrates findings on farmers' cropping decisions in relation to nutrition-related motivations. Their value for consuming a variety of self-cultivated crops is driven by knowledge around the importance of culinary diversity for 'eating enough', and awareness about the chemicals in commercially cultivated crops. Although they also have knowledge about the nutritional values of different crops, their values around aspirational crops and farm aesthetics are currently more prominent decision drivers.

Farmers in Dungariya have a strong value-knowledge linkage around culinary diversity, crop diversity and health, which leads to their belief that consuming a variety of self-produced crops is important for health. Respondents mentioned that without the culinary enjoyment of a varied diet, it is difficult to eat adequately and to get enough energy for work.

Table 4
Factors observed to operate in the decision-making process of crop portfolios in relation with nutrition-related considerations.

Values	Rules (system constraints)	Knowledge
Culinary diversity Consuming more aspirational crops (like rice over millets) Aesthetic of farms Consuming self-cultivated crops	Chemicals in market crops Land undulation, bunding, soil variability, irrigation (biophysical constraints)	Culinary diversity leads to 'eating enough' Health risks associated with commercially produced crops Nutritious crops Agricultural know-how

'If we make the same thing every day, then we don't like it and eat less. If it is tasty, we can eat a few more morsels. If you eat a lot, you can do hard work but if you eat less, how will you be able to work?' (male, 49). The community also values consuming subsistence produce, due to their knowledge around the chemical inputs in market produce.

Further, rather than considering dietary diversity important for nutritive balance, farmers generally mentioned one or two foods as 'healthy' (Fig. 4).

They also noted that they don't necessarily cultivate or consume 'healthy' crops. This is because of other decision drivers than nutrition-related knowledge. For instance, although farmers consider traditionally cultivated millets to be healthier than recently adopted rice varieties, this knowledge does not currently influence the decision context. One respondent (female, 33) elaborated that her family eats millets for strength and satiety during the labour-intensive monsoon sowing season. During illness, 'cold temperament' *(sheet)* foods like rice should be avoided, while eating 'warm temperament' *(garam)* foods like millets facilitates a quick recovery. Such awareness is part of the community's traditional knowledge. Several farmers, particularly the older generation, also commented that people have become weaker because of eating rice. "When we used to eat kodo and *kutki* (little millet), we never fell sick. We would walk twenty kilometres from Mandla without any difficulty. Now, people have become weak. This is because rice is 'hollow' and doesn't give us strength" (male, 55). However, this local knowledge of the long-term effects of rice consumption has only been created recently, a few years after the community started consuming rice in large quantities. This knowledge thus doesn't currently seem to be shaping the decision context. As described in Section 3.2, there is an aspirational value associated with cultivating and consuming rice. To cater to this value, farmers are also investing in irrigating, levelling and bunding their land to alter the biophysical constraints and cultivate the crop of their choice.

Consequently, the farmers' culinary values lead them to alter previously constraining rules to suit their aspirations and enable decisions which are contrary to their knowledge.

3.3.2. Household incomes

The community aspires to economic progress, but does not view crop diversification as the path to it. As visible in Table 5, increasing household income and having income stability are important values, and volatile market prices of produce form important rules-knowledge driving decisions.

Economic reasons were the second most cited advantage of maintaining a diverse portfolio (33%, $n = 24$) in response to the question 'why is it important to cultivate a diversity of crops?'. Farmers also keep close track of market prices. However, they seem sceptical about price stability and reluctant to make major investments in particular crops. One respondent (male, 34) gave an illustrative example. His family had

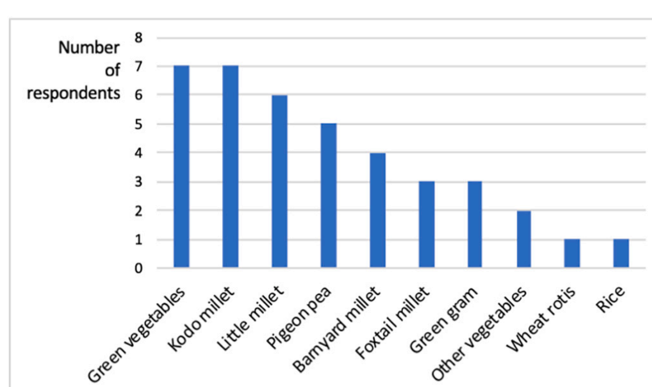

Fig. 4. Food items perceived as healthy, mentioned spontaneously during 24 semi-structured interviews.

Table 5
Factors observed to operate in the decision-making process of crop portfolios based on household income-related considerations.

Values	Rules	Knowledge
Increasing household income Income stability	Volatile market prices	Market prices and their volatility

planted a large area with tomato one year and had had a bumper harvest. However, the entire produce went to waste because the price was very low and they could not recover even their production costs. They now plant only as much as they can eat. Similar experiences were echoed by various farmers for other crops as well. Additionally, semi-structured interviews indicate that farmers intend to continue farming for self-sufficiency in household consumption regardless of their economic progress.

Their high value for income stability, along with knowledge on volatile market prices (along with their inclination to consume self-cultivated produce as far as possible) has contributed to their subsistence orientation. As a result, government procurement schemes or market prices do not significantly influence cropping choice in Dungariya.

3.3.3. *Environmental change adaptation*

Table 6 summarises the vrk interactions around adaptation. Farmers in Dungariya have traditional knowledge around diversifying to take advantage of temporal and geographical variability in environmental conditions. Further, they are aware of changing environmental conditions. However, they would like to grow the crops that they value (usually for culinary or aesthetic reasons), choosing to adapt to perceived environmental change through infrastructural development rather than through diversification. Crop diversification, consequently, does not currently appear to be the preferred path to coping with changing environmental conditions.

The decision-process for selection of paddy varieties is representative of the shift in farmer preference, from practising diversity-based risk management, to cultivating varieties dictated by culinary preferences while altering biophysical 'rules' to suit these tastes.

Since paddy cultivation in the village was traditionally rainfed and farmlands were undulating, the villagers developed knowledge of how to maximise the yields under system constraints of environmental variability. In *gehra* ('deep') land (flat, bunded and with black soil) capable of holding water for longer durations, they would plant long duration (*gahrun)* varieties which take 3–4 months to mature. In 'shallow' land (sloping, not bunded and with yellow soil), they would plant *halk*a ('light') varieties which mature over 2–3 months. They used their knowledge to assess the water-retention capacity of the land based on combined 'rules' of land slope, presence of bunding and quality of soil. They then exercised further knowledge to plant suitable *gahrun* or *harun* varieties. In recent times, farmers have noticed trends of higher summer temperatures and winter frost, and lower and more irregular monsoon rainfall. During the diversification exercise, they also confirmed that based on their knowledge, their traditional practice of multiple cropping different paddy varieties would be a sound adaptation strategy. However, this practice is no longer highly valued in the community.

Table 6
Factors observed to operate in the decision-making process of crop repertoires around environmental adaptation-related considerations.

Values	Rules (system constraints)	Knowledge
Culinary diversity Taste (flavour and texture) Visual aesthetic (food and crop)	Land slope Soil quality Bunding Changing environmental conditions (temperature and rainfall) Irrigation	Growing conditions for different crops varieties Water-holding capacities of different fields Changing environmental conditions (temperature and rainfall) Multiple cropping as a means of mitigating risk related to environmental variability Other adaptation options (e.g. irrigation)

As described in Section 3.2, their value for modern rice varieties and uniform green paddy fields over a patchwork of multi-cropped varieties has led to a reduction in the diversity of paddy varieties cultivated on fields. "We grow less variety of paddy now than we did ten years ago. Our parents' generation used to cultivate many native varieties, and now new varieties like 10-10 have come out which give better yield. These new varieties also have a fine texture, which is nice. The old varieties used to be coarse" (female, 50).

The influence of values on system constraints has enabled this transition. In recent times, farmers are digging wells, and levelling and bunding fields, allowing them to single crop fields with high water requiring paddy varieties. Accordingly, the diversification exercise revealed irrigation, rather than diversification to be the preferred coping strategy to environmental change in the village (Table 7).

The Four Cell Analysis (Fig. 3) suggests that all farmers plant the 'MTU 10–10' paddy variety over large areas because they like its fine texture and find it convenient to grow. Other varieties are cultivated by few farmers over smaller areas. Overall, there appears to be low varietal richness and evenness on individual fields, but relatively high divergence (different farms cultivate different native varieties), along with a loss of native varieties.

4. Discussion

4.1. *Crop diversity dynamics*

The crop diversity dynamics observed in Dungariya find resonance in the literature, where a tension between persistence and erosion has been recognised in various regions (Montenegro de Wit, 2015). While some authors have expressed concern over the erosion of traditional crop diversity (Wilkes, 1994), others have found increased species richness in areas with access to new resources and seeds (Brush, 1991; Jarvis et al., 2011). As described in Section 3.1., Dungariya seems to have witnessed both processes, the erosion of traditional diversity and enhancement of total diversity.

4.2. *Farmer decisions on crop diversity*

The vrk framework has been used for the first time to understand farmer-level decision-making around crop portfolios, and demonstrates that various interdependent factors are involved in decision-making. This research shows how values play a major role in shaping farmers' decisions. Specifically, the study illustrates, inter alia, the cultural shift in preferences for paddy and wheat over traditionally cultivated millets. Even though government procurement of certain crops over others (e.g. rice or wheat over millets) is a significant driver in several areas (Basavaraj et al., 2010; Michaelraj and Shanmugam, 2013), subsistence farmers in Dungariya are not influenced by such factors. While

Table 7
Results from the diversification exercise illustrating that the preferred adaptation response is irrigation rather than crop diversification.

Season	Observed weather changes	Preferred adaptation strategy
Summer	Increasing heat	Watering plants to prevent them from drying
Monsoon	Irregular rainfall and reduced precipitation overall	Watering plants when there is no rain
Winter	Increasing frost damage	Moistening the soil to prevent frost formation

excluding political and economic factors from the core of the analysis might initially seem like a drawback, it has actually been advantageous in illustrating the crucial role of values in communities insulated from the direct influence of market factors. Future studies should explore this further and probe the causes (including political and economic) of this shift in aesthetics and preferences.

The results of this study also demonstrate that while farmers may be economically motivated, increasing income need not be the only (or the most important) value shaping the agricultural decision context. This justifies the contention that it is necessary to use theories other than those predicated on assumptions of profit-maximisation under ambient environmental conditions to understand agricultural decision-making. The vrk framework is demonstrably a suitable heuristic for this.

As Gorddard et al. (2017) observe, 'the vrk heuristic provides a useful reminder of the limits of knowledge [or any other single factor] alone to change decisions.' This is exemplified in the case of Dungariya where most farmers remarked that they did not cultivate or eat what they know to be nutritious. Additionally, the farmers' rationale behind considering it healthy to consume various crops is a useful reminder that mainstream health perceptions can be different from 'folk' perceptions (Siu, 2012). Similar to observations from Dungariya, Powell et al. (2017) find that in the East Usambara Mountains, dietary diversity is considered more important for increasing appetite than for nutritional diversity. Recognising the importance of understanding local etiologies, they comment that 'as dietary diversity promotion becomes an increasingly common component of nutrition education, understanding local nutrition knowledge systems and local concepts about dietary diversity is essential to formulate efficient messages.'

Also, all twenty-four respondents affirmed that they would prefer to grow their own produce regardless of commercial affordability. Their aversion to chemical inputs is at odds with district-level data; the district Agricultural Census for the years 2001–02, 2006–07 and 2011–12 shows an increase in both the number and area of land holdings treated with pesticides and chemical fertilizers (Agriculture Census Division, Ministry of Agriculture and Farmers Welfare, n.d.). A possible explanation for the deviation from district trends is that the census data is predominantly from commercial farming. Subsistence farmers in Dungariya are more cautious of the health implications of additives and less driven by motivations to maximise productivity. In contrast with the community's strong inclination to grow their own food, Sibhatu et al. (2015, p. 10657) notice that the 'role of farm diversity for household nutrition' reduces with increase in market access. This contradiction reveals that the relationship between crop diversification and nutrition security is context-specific, and dependent on other factors, such as culinary preferences.

That climate resilience may be a co-benefit rather than the goal of diversification is another important result. Meldrum et al. (2017) observed in Bolivia that even households which appeared to be practising diversification-based risk management did not report it as an adaptation action. The failure to accord adaptation value to a diverse crop mix in Dungariya may be a similar phenomenon. Further, we recognise that increasing crop diversity enhances the resilience of agricultural systems and stabilises productivity in the face of varying environmental conditions. However, the thesis that farmers should cultivate a variety of crops to combat environmental variability is reasonable only if it is recognised that this is one of other options (Howden et al., 2007). Studies advocating for diversification-based adaptation sometimes assume that the system constraints of environmental fluctuations are limiting to such a degree that they set the decision context, and/or that farmers value cultivating a diversity of crops for the purpose of adaptation. However, the results point to the necessity of broadening the range of adaptation options beyond diversification.

4.3. Implications of farmers' decision-making on the crop diversity conservation paradigm

Demonstrating that changes in values have led to crop diversity erosion also has implications for the literature around nature-culture interactions and ethics of conservation strategies. That increasing contact with the outside world brought modern crop varieties and aspirations to cultivate more mainstream crops to Dungariya brings to the fore opinions around cultural homogenisation, the subsequent loss of biodiversity and conservation methods. Observations of biodiversity loss accompanying dietary and cultural homogenisation (Blundo-Canto et al., 2020; Khoury et al., 2014), can lead to suggestions that cultural diversity among producer-communities should be maintained for the purpose of conserving crop diversity (Lacy, 1994, p. 6). Such thinking invokes ethical questions around justice and positionality, like the 'Noble Savage/Fallen Angel myth' (Berkes, 1999, pp. 145–146), which advocates for indigenous peoples to be kept in a primitive state because otherwise, they will destroy their local environments (and in this context, reduce crop diversity). That farmers in Dungariya traditionally maintained native cultivars should not imply that they remain relegated to the same task.

Another patronising view justifying in-situ conservation is exemplified by, "We must realize that the loss of biodiversity will become a global crisis for all people and, particularly, the rural poor. For these people, the loss of biodiversity 'translates into loss of food, construction materials, medicine, fuel, and material inputs essential to their survival'" (cited in Lacy, 1994, p. 8). As applicable to Dungariya, assuming that indigenous communities must be 'saved' from an imposed reduction of diversity may be resultant of projecting the 'Noble Savage myth' (Buege, 1996) onto them. Trying to 'help' a community secure a set of resources that seem desirable from an external perspective, while ignoring local worldviews and aspirations is 'recognition injustice' (Martin et al., 2013). In addition, 'distributional justice' concepts (Vincent, 1998) also question the ethics behind placing the burden of diversity conservation for global gain on the shoulders of the poorest communities in the world.

The community in Dungariya has knowledge of the durations over which different seeds (especially local millet and paddy varieties) can be stored. However, seed-saving practices are gradually being discontinued. Interviewees often remarked that native seeds had 'drowned' and in general, did not seem concerned about saving them despite being aware of crop diversity erosion. 'We have stopped growing kodo and *kutki*. We used to save and use native seeds earlier but don't have any left since we sold everything' (female, 23). Since it is ethically questionable to force certain crops on unwilling farmers and because several farmers in Dungariya are uninclined to maintain native cultivars, the results of this study suggest that it may be more prudent to resort to ex-situ conservation practices. In a similar vein, Soleri and Cleveland (1993, p. 206) note that 'the potential benefits of in-situ conservation can only be realized if this strategy makes sense to the farmers.' This sentiment is echoed by Rana et al. (2005) based on a four-cell analysis in Nepal. Even Brush (1989, p. 19), one of the most vocal proponents of in-situ conservation qualifies his support for the strategy, stating that it is useful only 'if conservation rather than development is the priority'.

Ultimately, Lacy (1994, pp. 7–8) questions the extent to which we can conserve diversity. 'No matter how well we run our germplasm banks,… how many protected wilderness areas we create,… we shall never be able to assume responsibility for maintaining all life forms … we shall have to reconsider the limits of human ingenuity.' While Lacy makes a reasonable point, considerable crop diversity conservation still remains achievable. As Pelling (2011, p. 66) points out, rather than acting at the 'proximate' (the farm) level, perhaps the solution is to target a higher leverage point and address the 'root causes' of these problems. There are initial ideas for what solutions could look like. Blundo-Canto et al. (2020) suggest that interventions be developed at the landscape scale using interdisciplinary approaches and Sayre et al.

(2017) demonstrate how landscape-level activities can be integrated vertically with higher-level policy, and horizontally with other landscapes and communities. Such multi-scale interventions targeting systemic change while engaging with the grassroot levels could be starting points to tackling the more ultimate forces propelling climate change, poverty, malnutrition, cultural homogenisation, and the loss of crop diversity.

5. Conclusion

The importance of crop diversity has been widely recognised but there are debates regarding its current status and the best conservation strategy. Further, there is a need to understand the factors that motivate farmers to maintain certain crop portfolios because this has an immediate impact on the farmers themselves, as well as a cumulative effect on global-level plant genetic diversity. Identifying a gap in previous research on farmer-level decision-making, this study has used the framework of interacting values, rules and knowledge.

It has found that the level of crop diversity maintained by farmers in Dungariya Forest Village results from the balancing of their 'value' for high culinary diversity with 'rules' and 'knowledge' that can support it. Farmers value a high level of crop diversity for culinary purposes. They also consider it healthy to eat a variety of food. Being risk-averse, they are reluctant to cultivate crops much in surplus of household necessity, based on experience with fluctuating prices. Also, while farmers recognise diversity-based risk-mitigation as a realistic way to adapt to environmental change, they do not currently view this as the preferred strategy, choosing instead to control biophysical conditions to cultivate desirable crops.

Overall, based on semi structured interviews and the four-cell analysis, crop diversity appears to have increased in Dungariya, with some native crops simultaneously being lost. The influences behind these changes appear to be farmers' culinary and aesthetic values along with increasing ability to alleviate constraints such as water availability to support these preferences. While it is necessary to further investigate the social, political and economic forces shifting values, it is evident that the role of aspirations and culture is central to shaping crop diversity in this community. It is important to adapt conservation techniques according to the community's priorities. Given that current crop portfolios largely reflect the values of the community, it may not be fair or effective to force in-situ conservation of traditional varieties onto the farmers. For crops that seem particularly important to conserve, ex-situ practices may be more ethical and effective.

While substantive results, i.e. the values which drive cropping decisions, might vary, the argument that accounting for these values is relevant at the scale of central India (and indeed, beyond). With growing concern on the topics of crop diversity, food security and human well-being, it is essential to weave local-level perceptions of agriculture, nutrition, environment and development into narratives and actions on these issues at the global scale.

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Tanvi Agrawal. The first draft of the manuscript was written by Tanvi Agrawal, and all authors reviewed and edited the manuscript. Mark Hirons and Alfred Gathorne-Hardy supervised the research. All authors read and approved the final manuscript.

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Declaration of Competing Interest

There are no conflicts of interest. (Tanvi Agrawal worked as an intern at Bioversity International during the study. The fieldwork was also partially supported by Bioversity International. However, this information has been shared in the interest of full transparency and no conflict of interest exists.)

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Appendix A. Semi-structured interview guide questions

Age
Gender:
How many members are there in your family?
Which members are involved full-time in agriculture?
What are your household's main sources of income?

- How much land area do your fields cover? What kind of soil do they have? Do they have irrigation facility? Are they levelled and/or bunded?
- How many crops do you grow in each season?
- How do you decide which crops to grow and why do you grow so many?
- Can you list your five most important crops over the year?
- Why are each of these important to you? What do you get from cultivating them?
- How many varieties of each of these do you grow? Why do you grow these different varieties?
- Which of these do you sell and which do you keep for household consumption?
- Do you grow the same set of crops every year or do you practice crop rotation? Why? How long (how many years) is each crop rotation cycle?
- Are there crops that you would like to grow but are not able to? Why do you want to grow them?

- Where do you get seeds from? Do you save seeds at home?
- In general, do you think it makes a difference how many crops you cultivate?
- Which farmer in this village/nearby villages has the best farm? Why?
- How would you feel if you could buy, at an affordable price from the market, all the crops that you currently cultivate for household consumption?
- What are the main components in your everyday diet?
- How do you decide what to eat? What is the benefit of eating what you eat?
- Why do you think it is important to eat a variety of food?
- Do you think it is important to grow a variety of crops for health reasons?
- Do you make an effort to predict how much it will rain every year? What sources of information do you have/use for this?
- (If 'yes' for rain prediction) How do you act if your sources tell you that it will rain less/more than normal that year?
- How do you think adverse weather conditions can be dealt with?
- In general, do you think it makes a difference how many crops you grow on your fields to deal with adverse weather conditions?
- What have been the major changes in your crop mix over the past 10 years?
- Did you grow fewer/more crops at an earlier time? What is your opinion on the crop mix you maintained then?
- Did your ancestors grow a wider/smaller/different mix of crops than you do today? What is your opinion on that?

Appendix B. Table identifying the cereal, grain legume and oil seed species traditionally cultivated by the community in *kharif* and *rabi* seasons along with their local, English and botanical names

	Kharif season			*Rabi* season		
	Local Name	English Name	Botanical Name	Local Name	English Name	Botanical Name
Cereals	*Makka*	Maize	*Zea mays*	*Gehoon*	Wheat	*Triticum sp.*
	Chawal	Rice (Paddy)	*Oryza sativa*			
	Kodo	Kodo millet	*Paspalum scrobiculatum*			
	Kutki	Little millet	*Panicum sumatrense*			
	Sama	Barnyard millet	*Echinochloa frumentacea*			
	Kangni	Foxtail millet	*Setaria italica*			
Grain legumes (Pulses)	*Rahar*	Pigeon Pea	*Cajanus cajan*	*Chana*	Chickpea	*Cicer arietinum*
	Urad	Black Gram	*Vigna mungo*	*Batra*	Not identified	Not identified
				Masoor	Not identified	*Lens culinaris*
				Moong	Green gram	*Vigna radiata*
Oil seeds	*Ramtil*	Niger	*Guizotia abyssinica*	*Til*	Sesame	*Sesamum indicum*
				Alsi	Flax	*Linum usitatissimum*

Appendix C. Typical annual cropping calendar, generated during the diversification exercise

Season	Months	Hindu months	Monsoon activities	Winter activities	Summer activities
Summer	Mar - Apr	*Chait*		Harvest wheat	
	Apr - May	*Baisakh*			(if there is irrigation) Sowing of green and black gram, tomato, brinjal, okra, *barbatti*
	May–June	*Jesht*	Land preparation - levelling, tilling, adding manure, repairing bunds		Harvest of green and black gram, tomato, brinjal, okra, *barbatti*
	June–July	*Asadh*	Sowing of *kharif* crops: maize, paddy, *kodo, barnyard and foxtail millets,* pigeon pea, niger (as soon as it rains)		
Monsoon	July - Aug	*Savan*			
	Aug - Sept	*Bhado*	Sowing of little millet, weeding		
	Sept - Oct	*Kunwar*	Harvest of maize, sowing of sesame and leafy vegetables	Sowing of *rabi* crops: *Batra, masoor,* wheat, chickpea	
	Oct - Nov	*Kartik*	Harvest of remaining *kharif* crops		
Winter	Nov - Dec	*Agahan*			
	Dec - Jan	*Posh*			
	Jan - Feb	*Magh*			
	Feb - March	*Phalgun*		Harvest *batra, masoor* and chickpea	

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