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Culture, ethnicity, and crop choice: insights from tribal and non-tribal farmers in Adilabad District, India

Marijn Voorhaar[1,2] · **Vittal Rao Kumra**[3] · **Jana Kholová**[2,4] · **Vincent Garin**[5,6]

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Abstract

Efforts to increase the adoption of modern crop varieties among smallholder farmers have limited success, especially among vulnerable communities. We argue that, before analyzing constraints to adoption, we first need to understand why farmers decide to cultivate certain crops. Beyond well-known (environmental, socio-economic, technological, and policy related) factors, the role of ethnicity and culture is relevant as well. We investigate how ethnicity and culture are correlated with crop choice during the post-rainy season among farmers in Adilabad District, India. We adapted the Hofstede Cultural Values Scale to operationalize and measure culture in these farming communities. It represents a tool to characterize culture along six dimensions, including attitudes toward change, individualism, and masculinity. Our results show significant differences between tribal and non-tribal farmers in terms of crop choice and cultural values, and these two types of variables "hang together" in an intuitive way. Tribal farmers mostly grow sorghum for subsistence and fodder purposes, while non-tribal farmers focus on producing cash-crops (chickpea, rice, maize). They also have weaker preferences for hierarchy, display a more collectivist (less individualistic) attitude, and show greater resistance to changing their traditional ways. Farmers' ethnic and cultural background should be taken into consideration when breeding or designing interventions aiming to increase dissemination of new varieties.

Keywords Culture · Ethnicity · Technology adoption · Smallholder farmers · Tribal communities

Abbreviations

ANOVA	Analysis of Variance
CCD	Centre for Collective Development
ICC	Intraclass Correlation Coefficient
INR	Indian Rupee
NGO	Non-Governmental Organization

Introduction

Despite efforts to increase the adoption of new crop varieties among smallholder farmers in low-income countries, adoption rates remain low, especially among vulnerable communities (Diagne 2009; Kabunga et al. 2012; Aryal et al. 2018; Mausch et al. 2018). Several reasons for low

✉ Marijn Voorhaar
marijn.voorhaar@gmail.com

Vittal Rao Kumra
vittalrao.utr@ccd.ngo

Jana Kholová
kholova@pef.czu.cz

Vincent Garin
vincent.garin@cirad.fr

[1] Department of Social Sciences, Development Economics (DEC), Wageningen University & Research, Hollandseweg 1, Wageningen 6706 KN, The Netherlands

[2] Crop Physiology and Modelling, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Telangana 502324, India

[3] Centre for Collective Development (CCD), Utnoor, Telangana 504311, India

[4] Department of Information Technologies, Faculty of Economics and Management, Czech University of Life Sciences, Kamýcká 129, Prague 16500, Czech Republic

[5] CIRAD, UMR AGAP Institut, Avenue Agropolis, Montpellier F-34398, France

[6] UMR AGAP Institut, Univ Montpellier, CIRAD, INRAE, Institut Agro, Avenue Agropolis, Montpellier F-34398, France

adoption rates have been identified: absence of resources, risk avoidance, limited availability, and effectiveness of extension services (Acevedo et al. 2020), as well as a lack of context specificity of the new technology (Evenson and Gollin 2003). Although research and development of new cultivars receive significant attention and resources, less work is put into facilitating the uptake of these innovations by smallholder farmers (Kholová et al. 2021; Van Etten et al. 2023). With up to 80% of unused new cultivars (Thiele et al. 2021) and the majority of farmers unable or unwilling to adopt them, the benefits of these efforts are minimal. While most of the literature focuses on constraints (e.g. information constraints, liquidity/cash constraints, availability constraints), much less attention is paid to what farmers want, need, and aim to achieve in their specific farming conditions (i.e. the objective function). This connects to the fact that non-adoption could also be rational. For example, farmers can decide not to adopt an innovation when their personal goals are not met (Pannell et al. 2006), when the risk and uncertainty are too high (Geertz 1963; Vanclay 2004), or when the technology is too complex (Vanclay and Lawrence 1994). Yet, to understand the complex mechanisms behind crop and cultivar adoption, we first need to have a closer look at why farmers choose to cultivate a certain crop.

The determinants of crop choice among smallholders have been widely researched and imply a combination of environmental, socio-economic, technological, psychological, and policy-related factors (Sakane et al. 2014; Wang et al. 2017; Amare et al. 2018). Additionally, the influence of the farmers' ethnicity and culture on crop choice receives slowly more attention and acknowledgement (Labeyrie et al. 2014; Acevedo et al. 2020; Wendmu et al. 2022). However, for technology adoption the cultural background and values of the farmers are often not considered, as the emphasis of conventional plant breeding still lies on the development of high yielding and profitable cultivars (Bassi et al. 2024). If ethnicity and culture play a role in farmers' decision-making process concerning the crops they select to cultivate, investigation of the ethno-cultural context of the farmers could potentially increase the understanding of why certain technologies are adopted while others are not. Presumably, this could help to refine variety selection and therefore the opportunity for farmers to have access to cultivars they are actually willing to adopt.

While ethnicity has no universally accepted definition, it typically refers to a social construct that classifies groups of people who identify with each other based on shared attributes that are often inherited, such as ancestry and heritage, common history (e.g. migration patterns), language and religion (Horowitz 2000; Chandra 2006). Culture, on the other hand, is something that is shared by different ethnic groups, and consists of behavior, beliefs, values and customs (Chandra 2006; Wedeen 2002), that make people look at the world from a certain perspective. Unlike ethnicity, culture is more dynamic and might change over time as societies transform, adapt to new circumstances or blend with other cultures. While members of an ethnic group usually share a common culture, not all members of a culture share the same ethnicity (Bates 2004). Desmet et al. (2017) describe ethnic identity as a significant predictor of cultural values.

According to the Dutch organizational psychologist Hofstede (2011), "Culture is the collective programming of the mind that distinguishes the members of one group of people from others (p. 3)."[1] Hofstede developed a framework and tool to operationalize, measure, and compare cultural values within societies, and show how they influence people's behavior, decision making, and communication with each other (Hofstede 1983, 2011). The Hofstede Cultural Values Scale consists of six dimensions along which cultural values could be analyzed in a quantifiable way: Power Distance, Individualism, Uncertainty Avoidance, Masculinity, Long-term orientation vs. Short-term orientation, and Indulgence vs. Restraint. The different dimensions are described as follows:

1. **Power Distance**: the extent to which members of a society expect and accept unequal power distribution.
2. **Individualism**: the extent to which members of a society see greater value in attaining personal or community goals.
3. **Uncertainty Avoidance**: the extent to which members of a society experience stress in the face of an unknown future.
4. **Masculinity**: the extent to which members of a society favor achievement, competition and material rewards over relationships and quality of life. This dimension is also related to the division of emotional roles between men and women.
5. **Long-term vs. Short-term orientation**: the extent to which members of a society favor a more pragmatic approach, to prepare for the future, or if they choose to focus more on the present and the past.
6. **Indulgence vs. Restraint**: the extent to which members of a society allow free gratification or control regarding basic human desires related to enjoying life.

Using Hofstede's cultural dimensions could be a meaningful approach to analyze the relationship between farmers' culture, crop choice and ultimately, technology adoption.

[1] The original Hofstede Cultural Values Scale was created to measure country differences between IBM employees. However, in the last four decades, this method has been applied to a wide range of topics in social sciences, psychology, marketing, management and economics (Ang 2015).

Numerous studies have demonstrated the versatility of Hofstede's cultural dimensions across diverse fields and settings, with some addressing questions related to our own research. Srite and Karahanna (2006) for example, used the framework to get a better understanding of cultural influences on technology adoption, while Escandon-Barbosa et al. (2022) used Hofstede's dimensions to analyze the relationship between cultural values and people's perspective on innovation.

Research objectives and questions

Despite the growing interest in the topic of how culture influences crop choice, studies lack the methodology to measure this relationship and quantify culture in a farmer context. Moreover, understanding the role of culture in shaping farmers' cultivation and adoption choices requires further research, as the disconnect between breeders' innovations and the actual needs of the farmers may be influenced by cultural factors. To explore how the farmers' culture can influence crop choice and technology adoption, we will introduce a method, based on an adapted version of Hofstede's cultural dimensions, to characterize farmer communities, using ethnicity and cultural values as a central frame of reference to understand farmers' choices regarding crop cultivation. To the best of our knowledge, no prior studies have used Hofstede's Cultural Values Scale to quantify farmers' cultural values and their influence on agricultural practices, especially crop choice.

In this paper, we will go back to the 'roots' of the farmers, while answering the following research questions (RQ): (RQ1) Can we use an adaptation of the Hofstede Cultural Values Scale to detect cultural differences between smallholder farmers living in the same area?; and if yes, (RQ2) Do these cultural differences play a role in farmers' selection of crops to cultivate?; (RQ3) What is the influence of other determinants such as environment and socio-economic status on crop choice? and ultimately, (RQ4) What matters most for crop choice: geography, demographics, culture, or a combination of these?

We expect to find that ethnicity and culture are important drivers of crop choice, particularly among farmers from traditional communities with distinct cultural characteristics, such as tribal groups. Despite the completely different context and application of the original Hofstede framework, we argue that these cultural dimensions could offer an insightful method for analyzing the cultural factors that affect the farmers' crop choice. For example, a higher score on Power Distance could indicate that farmers tend to follow the advice of an authority, in terms of which crop to grow. Farmers with a low score on the Individualism dimension might prefer to cultivate crops that are valued by the community, such as sorghum. A high level of Uncertainty Avoidance could tell us something about how conservative a farmer is and if they would have a tendency to select more traditional crops.

Our study site, the Utnoor Mandal (district political subdivision) in the Adilabad District, India, gives us the unique opportunity to research farmer communities that are highly heterogeneous in terms of ethnic background and farming system in a relatively small area (Fig. 1b). This allows a direct comparison of those populations sharing a common environment with important variations. During the post-rainy (Rabi) season these smallholder farmers cultivate four main crops: sorghum, chickpea, rice, and maize. The different nature of these crops – sorghum being a traditional crop, mostly used for subsistence, while chickpea, rice, and maize are considered cash crops – makes for an interesting comparison between cultivation behavior, environment and culture. In the Adilabad region, sorghum cultivation has been declining since the 1980s, which is in line with the global Indian trend (Nagaraj et al. 2013). Yet a substantial part of the smallholder farmers in this area continues to grow this traditional crop, especially during Rabi season, when sorghum is used for household consumption and animal feed (Nagaraj et al. 2013; Chapke et al. 2014). The district is also characterized by a high cultural diversity. The important fraction of tribal communities (16.7% of the district belongs to scheduled tribes, compared to 6% in Telangana state) gives us the opportunity to get insight in the cultural values and behaviors of those who keep sorghum cultivation alive in this region. In India, tribal people are commonly referred to as *Adivasis*, as they are considered the original inhabitants of the land, preserving their unique territorial and cultural identity (Singh and Singh 2017). There are 450 different tribal communities in India, the rest of the population consists of non-tribal people. Non-tribal people mostly practice Hinduism and are classified into four main castes (Iyer and Parvathi 2023). Assuming that farmers do not easily change their culture according to different circumstances, the cultural variables can be considered exogenous (Koprowski et al. 2021). Especially for the Gond, Kolam, and Pradhan tribes, sorghum has a distinctive cultural importance; not only is the crop their staple food, the sorghum plants are seen as divine and are highly important for their *puja* (worship) rituals (Pandravada et al. 2013). Additionally, these tribes have a preference for specific landraces and varieties because of their 'sweet' taste (Nagaraj et al. 2013).

Culture, technology adoption, and crop choice: A literature review

Previous studies have shown the importance of culture for innovation and technology adoption, mostly in disciplines

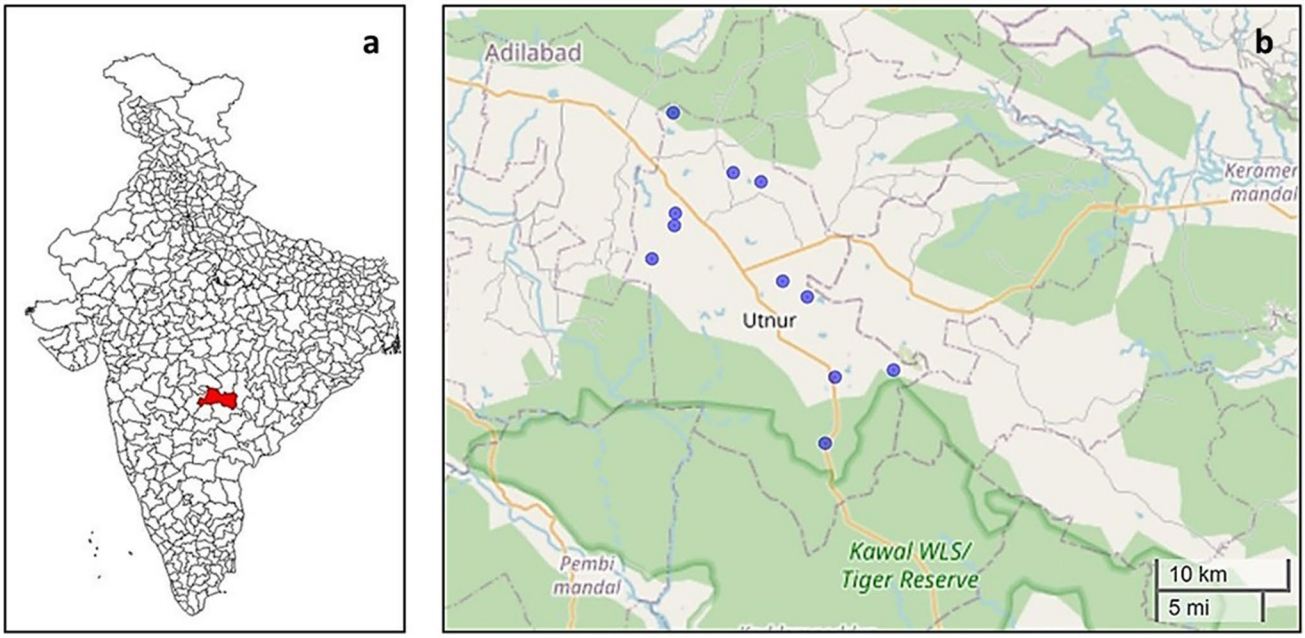

Fig. 1 Location of Adilabad District in India (**a**) and villages included in our study (**b**)

such as economics, marketing, management, sociology, and psychology (Mokyr 2008, 2014; Ang 2015). Mokyr (2008, 2014) states that understanding variations in technology adoption from the perspective of culture is relevant, because a person's beliefs, norms, and values can either stimulate or slow down technological innovations. He describes cultures as accumulated experiences which shape perceptions and determine preferences and priorities that could affect decision making in favor of tradition or innovation. According to Gorodnichenko and Roland (2011), the dimension of culture that is the most impactful for economic growth, is individualism, which refers to positively valuing individual freedom, opportunity, achievement, advancement and recognition. An individualistic culture will therefore encourage technological development. According to Mokyr (2008) the attitude toward change and tradition that can be generally described as conservatism, also has a strong connection to the acceptance of innovation.

The relationship between farmers' culture and their willingness to adopt new technologies has rarely been studied directly. Results of a study conducted by Palis (2006) showed that farmer field schools embracing local cultural norms encouraged experiential and collective learning and eventually resulted in adoption of integrated pest management among Filipino farmers. Arvila et al. (2018) conducted a study that showed how tribal affiliation and language of the Maasai in rural Tanzania influenced their decision-making process and willingness to adopt new agricultural technologies. The cultural identity of the participants in these studies was determined; however, it was not evaluated through explicit measurement. Hofstede's Cultural Value Scale would enable us to use a structured and quantifiable approach to assessing cultural values. By translating abstract cultural concepts into six measurable dimensions, the model allows us to systematically evaluate and compare cultural attributes across different groups or societies.

Literature about the determinants of crop choice among smallholder farmers predominantly describes variables like the natural environment (e.g. soil, water availability), socio-economic factors (e.g. access to extension services), demographics (e.g. age, education), technology (e.g. use of fertilizers), behavior (e.g. estimation of costs and benefits) and policy (e.g. crop subsidies). From a macro-level and evolutionary perspective, it is well established that crops develop environmental-specific adaptations, which strongly determine their performances in a given environment (Harlan 1992). For example, in crops like millet, Bidinger et al. (2008) and Garin et al. (2023) documented that in environments prone to severe drought stress, farmers tend to keep growing traditional varieties that are more adapted to the local conditions. Studies have also shown that socio-economic elements, such as access to new technologies and extension services, facilitate the transition from traditional crop cultivation towards 'modern' crop cultivation (Ebert 2014). For example, Yang et al. (2017) and Dedeurwaerdere and Hannachi (2019) have shown that farmers with better access to technology extension services prefer to plant modern hybrid rice varieties rather than traditional landraces. Government policies, especially subsidies can also be a major driver of crop choice, as seen in the transition from

sorghum to rice cultivation in India (Nagaraj et al. 2013; Chapke et al. 2014). This transition was probably accelerated by the Green Revolution, which included a focus on high-yielding and high-imput commercial crops – wheat, rice, and maize – resulting in policies favoring their cultivation, while shifting away from coarse cereals, such as sorghum (Pingali 2012; Eliazer Nelson et al. 2019).

In terms of demographics, variables such as age, education, and economic means have shown significant effects on crop choice. However, studies found mixed results on the effect of age. Rogers (2003) and Awotide et al. (2016) found that younger farmers were more open to innovations and adopted more productive crops and varieties. Contrastingly, Appleton and Balihuta (1996) found that age was a non-significant variable for crop choice. The farmer's level of education has also been shown to be critical for crop choice, with studies indicating that more educated farmers tend to prefer agricultural systems that rely on more inputs (Nkamleu and Adesina 2000) or that are more diversified (Rahman 2008). However, when a new technology is rather complex, the farmer's level of education may reduce or delay adoption due to recognition of the possible limitations of the innovation (Marsh et al. 2000).

Ultimately, the choice for a certain crop is influenced by behavioral factors, like the household's intended usage. When farmers cultivate crops mostly for marketing purposes, they tend to choose high yielding crops requesting more inputs and more structured value chains. Such trends explain the replacement of many traditional crops by more productive and market-oriented species, such as rice, maize, or cotton (Matsa and Mukoni 2013). According to Wang et al. (2016), the choice for a particular crop also reflects the attachment to local food consumption habits, which is closely related to the farmers' ethnic and cultural background (Teeken and Temudo 2021). Undoubtedly, crops do not only represent biological entities; they also carry the cultural signature of the societies cultivating them. Thus, the farmer and consumer preferences can largely explain the persistence of traditional cropping systems, for example rice in China (Dedeurwaerdere and Hannachi 2019), maize in Mexico (Perales et al. 2003), or potato in Bolivia (Almekinders et al. 2009).

In the following sections, we start with a description of our research site, population and methodology. Subsequently, we look at the results regarding the farmers' cultural values and how they can be interpreted and used to better understand their behavior. We then create farmer characterizations and try to identify if sorghum farmers stand out. Finally, we will discuss the implications of the study results for future interventions and breeding programs.

Materials and methods

Study site

In addition to the cultural diversity mentioned in the introduction, the Adilabad District (North Telangana state, Fig. 1a) is an agro-biodiversity hotspot (Pullaiah et al. 1992), due to a unique mix of landscape and soil characteristics. Adilabad's landscapes vary from hilly to plain areas, with a considerable surface covered by forests (~40%) and an important number of lakes, rivers, and waterfalls (Reddy et al. 2018). About 38% of Adilabad's surface is dedicated to agriculture. Black and red soils are the most common soil types, with black soil covering the largest surface (72%) (Reddy et al. 2018). The farmers in Adilabad cultivate a large variety of crop species. Except for pearl millet, all the most cultivated crops in India, such as sorghum, chickpea, rice, maize, cotton, soyabean, pigeonpea, and wheat, are cultivated there in a substantial proportion (http://data.icrisat.org/dld/). This can make the region representative for many trends in Indian agriculture (Pullaiah et al. 1992). For example, in this relatively small area we can observe the existing tension between traditional crops (e.g. sorghum) and market-oriented crops (e.g. rice, maize, and chickpea).

Village selection and recruitment of participants

Our study was conducted in November 2020 in 11 villages of the Utnoor Mandal. The villages (tribal, non-tribal, or mixed) were selected to be representative of the four main crop systems (sorghum, chickpea, rice, and maize) practiced in this area during the Rabi season (October – April), as well as the cultural and environmental diversity of the region. In each village we interviewed 110 farmers (male: $N=89$ and female: $N=21$), with a specific effort to include at least two women per village. Farmers were recruited with the help of the Centre for Collective Development (CCD). This NGO supports smallholder farmers, with a specific emphasis on tribal farmers. Due to the heterogeneous nature of the target population (e.g. limited availability during daytime, social structure of the village), it was difficult to realize a strict randomized sample that would guarantee the maximum level of representativeness. Therefore, participants were recruited using a snowball strategy, which aims to select individuals with certain desired characteristics by using the participant's social network to recruit similar people (Sadler et al. 2010). Additionally, we selected participants through consecutive sampling (Setia 2016), which is selection based on target criteria (e.g. cultivation of at least one Rabi crop, age, at least two women per village). A total of 59 participants belonged to the tribal communities in the area

(Kolam, Gond, Pradhan, Naikpod, and Lambadas), while 51 participants were classified as non-tribal.

Household survey

Based on the literature mentioned in the introduction, household surveys were developed to collect data for this study (For a complete version of the questionnaire see Supplementary Information: SI1). The survey questions covered the following subjects: demographics (e.g. household size, level of education), ethnicity (belonging to a certain tribal group or non-tribal), an adapted version of Hofstede's Cultural Values Scale (Hofstede 1983, 2011), crops cultivated during Rabi and Kharif (rainy season), soil and environmental pressure (e.g. drought), and access to technology (e.g. use of fertilizers). Census demographic data at the village level like the total population per village or the percentage of women were also added to the data (https://www.census2011.co.in/). Finally, we complemented the data with the distances between the villages and the main road, as well as water sources measured with Google Maps.

Table 1 Examples of Hofstede questions adapted to the context of smallholder farmers in Adilabad District, India

P1	Power Distance	P2
Every farmer should have equal access to land	1 2 3 4 5	Some people (e.g. farmers with more means, head of the village) can have better access to land
	Individualism	
People should take care of the whole community/village	1 2 3 4 5	People should first take care of themselves and their families
	Uncertainty Avoidance	
Getting a loan to cultivate a new crop is worth it	1 2 3 4 5	Getting a loan to cultivate a new crop is risky and should be avoided
	Masculinity	
Decisions about farming should be taken by men and women	1 2 3 4 5	Decisions about farming should rather be taken by men
	Long-term vs. Short-term orientation	
I would like my children to be farmers as well	1 2 3 4 5	I will accept if none of my children want to become a farmer
	Indulgence vs. Restraint	
It is important to often take a rest and enjoy life	1 2 3 4 5	It is important to always continue to work hard

Hofstede's cultural values scale

The respondents were asked to answer questions regarding each of the six dimensions. Each question consisted of two contradictory propositions (P1, P2; Table 1). A five-point Likert scale was used to determine the proposition the respondent agrees most with. The respondent could choose between: total agreement with P1 (1); partial agreement with P1 (2); equal agreement with P1 and P2 (3); partial agreement with P2 (4); and total agreement with P2 (5). Examples of questions for each dimension used for the farmers are shown in Table 1. A complete version of the Hofstede questionnaire can be found in the Supplementary Information (SI1). We purposely did not assign any numeric values to the Likert scale presented to the farmers, in order to avoid giving the impression that they receive a score for each answer. Numerical values were assigned after the interview. The participants were asked to answer five questions per dimension. For each dimension, we calculated a total score by summing the scores of each question.

Focus groups

The individual quantitative surveys data were complemented by five focus group discussions with 5–20 farmers to discuss crop choice, crop usage, cultural practices, and environmental pressure, as well as the future of farming in Adilabad. The focus group data was used to triangulate the information from the questionnaire and to complement this with qualitative data. The focus groups were conducted per village and villages were selected given the farmers' availability. Each main crop (sorghum, chickpea, rice, or maize) was represented by at least one village. Tribal people and non-tribal people were mostly interviewed separately due to the composition of their villages, however, a few villages were mixed. Women were not excluded from the focus group, but tended to be more reluctant to participate in the group discussions and felt more comfortable watching from the side. Hence, the data from the focus groups reflected the views of the men in our sample.

Descriptive statistics and univariate analysis

For each explanatory variable, we calculated the mean and standard deviation. We measured the strength of association between the explanatory variables and the variables of interest (ethnicity and main crop) by estimating the significance of the mean difference between groups using a t-test or an analysis of variance (ANOVA). The differences between the means were considered to be significant if the p-value of the test statistic was below 0.05.

For each variable we calculated the intraclass coefficient (ICC). The ICC determines how strongly the individuals of the same group resemble to each other when measurements are made on individuals belonging to different groups, for example farmers belonging to the same village (Koch 2004). We calculated the ICC with the following formula; $\sigma_v^2/(\sigma_v^2 + \sigma_e^2)$ with σ_v^2 representing the village level variance and σ_e^2 the error variance that were estimated with a simple linear mixed model ($y = \mu + x_{village} * \beta_{village} + e$). The within-village resemblance decreases with the ICC from 1 to 0. When the ICC=1, all individuals of the same village have the same value. An ICC value of 0 means that all variation happens between individuals and that there is no variation between the different villages (means). This means that population structure in villages can be ignored and that all individuals can be considered to come from a single population. Therefore, the ICC helps to determine the level of data structuration (per village), which strongly influences the type of statistical analysis that can be performed.

Results

Ethnicity and Hofstede's cultural values

This section presents the findings of our study, which aim to answer the question whether we can measure cultural differences between smallholder farmers of different ethnicities using Hofstede's dimensions (RQ1). We first start with a visualization of the results using radar charts (Saary 2008), which provide an efficient way to simultaneously visualize the six cultural dimension results. Subsequently, we present a more detailed table with the scores for all Hofstede questions separately, grouped by tribal and non-tribal respondents.

The visualization of the total cultural values scores for tribal and non-tribal respondents is shown in Fig. 2a. For four out of the six cultural dimensions, tribal and non-tribal farmers received significantly different scores. Tribal farmers showed lower levels of Power Distance, Individualism, and Masculinity compared to non-tribal respondents. Contrastingly, higher levels of Uncertainty Avoidance were measured among tribal farmers. The same four dimensions showed significant differences when participants are divided into different ethnic groups (Fig. 2b).

The results shown in Table 2 indicate that tribal farmers preferred a less hierarchical society, reflected by their total score on the Power Distance dimension being significantly lower than the score of non-tribal farmers (m_T = 11.07; m_{NT} = 13.96, $p < 0.001$). A further decomposition given tribal groups and non-tribal farmers (Fig. 2b) show that the non-tribal group show the highest preference for a differentiated society while the most traditional tribal groups like the Kolams and the Gonds preferred a more equalitarian society. Interestingly, the tribal groups (Lambada, Naikpod) whose lifestyle became more similar to non-tribal people over time (Fürer-Haimendorf 1982; Roshni 2021), received intermediate scores. While tribal farmers more often considered farmers themselves as experts in the field who should

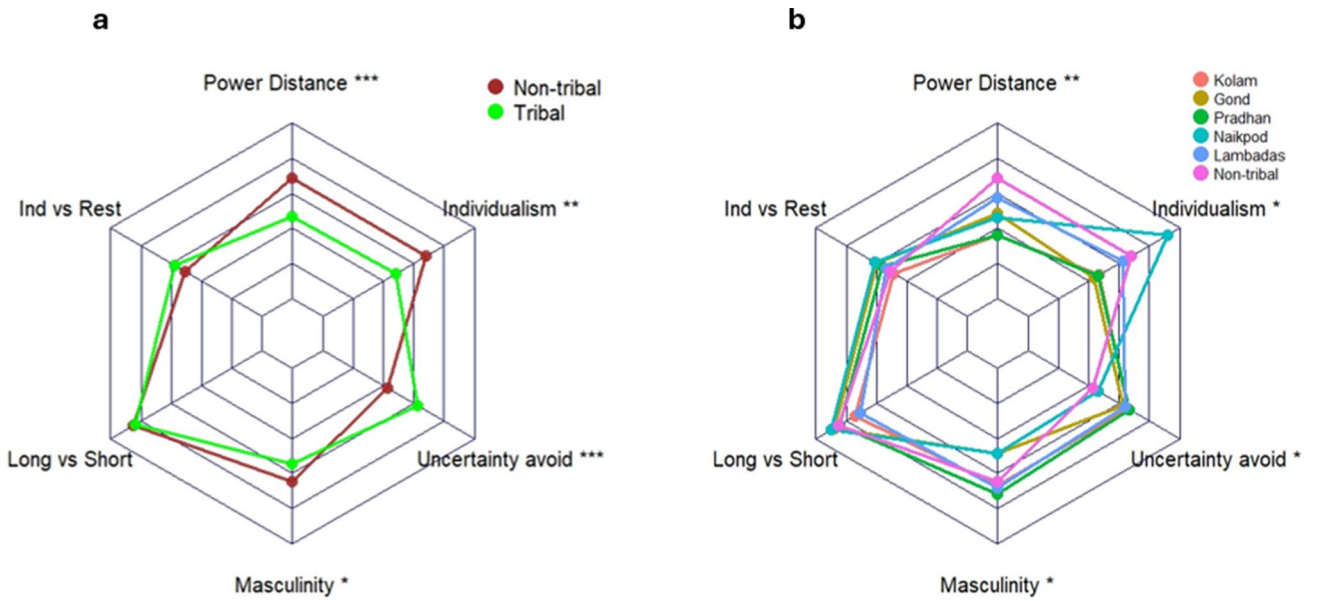

Fig. 2 Radar charts of the average score of each Hofstede cultural dimension (Power Distance, Individualism, Uncertainty. Avoidance, Masculinity, Longterm vs. Short-term, and Indulgence vs. Restraint) for different grouping categories: **a**) Tribal vs. non-tribal; and **b**) Ethnic group. The stars represent the significance of the difference between the groups estimated with a t-test or an ANOVA (*: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001)

Table 2 Cultural values (Hofstede): tribal vs. non-tribal farmers

	Tribal (N=59)	Non-tribal (N=51)	p-val	ICC
Equal society vs. hierarchy [1–5]	1.58 (1.23)	2.22 (1.74)	0.031*	0.05
Old young equal vs. more respect elderly [1–5]	3.29 (1.87)	3.98 (1.61)	0.039*	0.18
Equal access land vs. different access land [1–5]	2.78 (1.67)	3.43 (1.62)	0.04*	0.11
Own decisions vs. government advice [1–5]	1.98 (1.33)	3.04 (1.68)	0.000***	0.04
Equal relation gods vs. some closer to gods [1–5]	1.44 (1.09)	1.29 (0.7)	0.397	0.12
Power Distance [total: 5–25]	11.07 (4.09)	13.96 (3.82)	0.000***	0.24
Community vs. self and family [1–5]	2.56 (1.8)	2.92 (1.83)	0.3	0.06
Loyalty group vs. own choices [1–5]	2.05 (1.54)	2.67 (1.68)	0.049*	0.06
Opinion others vs. opinion self [1–5]	2.75 (1.83)	3.90 (1.68)	0.001***	0.20
Crop advise others vs. crop advise self [1–5]	2.31 (1.73)	2.28 (1.88)	0.943	0.19
Respons. community vs. respons. self [1–5]	1.64 (1.37)	2.08 (1.54)	0.125	0.16
Individualism [total: 5–25]	11.31 (4.12)	13.86 (5.66)	0.01**	0.16
Innovation vs. tradition [1–5]	2.15 (1.48)	1.22 (0.84)	0.000***	0.13
Investment worthy vs. investment risky [1–5]	2.12 (1.33)	1.94 (1.36)	0.491	NA
Farming stressful vs. farming happy [1–5]	4.68 (0.75)	3.74 (1.63)	0.000***	0.18
Multiple activities vs. only farming [1–5]	3.53 (1.71)	2.20 (1.71)	0.000***	0.25
Personal freedom vs. laws and rules [1–5]	4.03 (1.5)	2.94 (1.93)	0.002**	0.11
Uncertainty Avoidance [total: 5–25]	13.15 (3.39)	10.56 (3.8)	0.000***	0.18
Farm. tasks same vs. farm. tasks different [1–5]	4.54 (1.13)	4.5 (1.23)	0.853	0.09
Decisions together vs. decisions by men [1–5]	1.37 (1.05)	1.46 (1.23)	0.695	0
Empathy and support vs. competition [1–5]	2.92 (1.68)	3.64 (1.54)	0.021*	0.18
Equal education vs. favor talented child [1–5]	1.88 (1.37)	2.10 (1.52)	0.434	0.14
Girls study first vs. girls marry soon [1–5]	1.37 (1.02)	1.66 (1.24)	0.194	0.06
Masculinity [total: 5–25]	12.08 (2.96)	13.36 (3.24)	0.035*	0.24
Child other job vs. child continues farming [1–5]	2.02 (1.32)	2.38 (1.52)	0.191	0.22
Change practices vs. follow ancestors [1–5]	2.58 (1.78)	1.78 (1.36)	0.01**	0.27
Spend money on special occasions vs. saving [1–5]	3.68 (1.38)	4.02 (1.25)	0.179	0.10
Quick change vs. patience [1–5]	3.49 (1.81)	3.74 (1.71)	0.464	0.11
Fast fix vs. consideration [1–5]	4.17 (1.4)	4.12 (1.49)	0.86	0.05
Long-Term vs. Short-Term [total: 5–25]	15.93 (3.65)	16.04 (3.59)	0.877	0.24
Control own life vs. external factors [1–5]	2.36 (1.58)	2.48 (1.89)	0.714	0.03
Rest and enjoy life vs. work hard [1–5]	4.76 (0.6)	4.44 (1.18)	0.084	0.12
Gods are forgiving vs. gods feared [1–5]	1.90 (1.59)	1.42 (1.07)	0.066	0.02
Optimism vs. pessimism [1–5]	1.73 (1.35)	1.72 (1.29)	0.972	0.26
Share emotions vs. keep emotions inside [1–5]	1.75 (1.5)	1.58 (1.18)	0.521	NA
Indulgence vs. Restraint [total: 5–25]	12.49 (2.82)	11.64 (3.05)	0.136	0

Mean values and standard deviations (SD, in parenthesis); *: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001

make their own decisions, non-tribal farmers showed a higher preference towards decision making by 'experts', such as the government (m_T = 1.98; m_{NT} = 3.04, $p <$ 0.001). Additionally, tribal farmers considered smaller differences between people as something good, whereas non-tribal farmers valued a type of society with more differences between people (m_T = 1.58; m_{NT} = 2.22, p = 0.031).

Concerning Individualism, tribal farmers showed preference for a less individualistic society (m_T = 11.31; m_{NT} = 13. 86, p = 0.01). The non-tribal and less traditional tribes like the Naikpods were more individualistic than the more traditional tribes (Kolam and Gond, Fig. 2b). This attitude was supported by a significantly higher sensitivity to the opinion of other people of the community (m_T = 2.75; m_{NT} = 3.90, p = 0.001) and higher a degree of loyalty to the community for social engagements, such as marriages or friendships (m_T = 2.05; m_{NT} = 2.67, p=0.049). We found significantly higher levels of Uncertainty Avoidance among the tribal farmers in our group (m_T = 13.15; m_{NT} = 10.56, $p < 0.001$). For this dimension, all the tribal groups, except for the Naikpod, showed similar levels of Uncertainty Avoidance contrasting with the non-tribal farmers (Fig. 2b). Looking at the individual questions, we observed that in contrast to the non-tribal farmers, tribal farmers considered farming to be less stressful (m_T = 4.68; m_{NT} = 3.74, $p < 0.001$) and they were more likely to continue practices that had worked in the past (m_T = 2.15; m_{NT} = 1.22, $p < 0.001$). Besides, tribal farmers preferred to focus solely on farming, while non-tribal farmers showed more interest in engaging in multiple activities (m_T = 3.53; m_{NT} = 2.20, $p < 0.001$).

Smaller differences were found on the Masculinity dimension, implying tribal farmers to be slightly less masculine than non-tribal farmers (m_T = 12.08; m_{NT} = 13.36, p = 0.035). This was mostly reflected in the question concerning empathy vs. competition. The tribal farmers put more emphasis on showing empathy and support for everybody in the community, while the non-tribal farmers seemed to have a higher interest in competition (m_T = 2.92; m_{NT} = 3.64, p = 0.021). Masculinity was the only cultural dimension that showed a difference between the men and women in our sample (m_{men} = 13.07; m_{women} = 11.0, p=0.001; Supplementary Information: SI2, Table 1; SI3, Fig. 1). Women were more inclined to think that men and women can do the same task (m_{men} = 4.75; m_{women} = 3.57, $p <$ 0.01). Additionally, women were significantly more in favor of letting girls study first before marriage (m_{men} = 1.59; m_{women} = 1.14, $p <$ 0.01). On the dimensions of Long-term vs. Short-term and Indulgence vs. Restraint, no significant differences between tribal and non-tribals were found. The ICC score taking values between 0.16 and 0.24 for five out of six dimensions, shows that cultural orientation tended to be shared within the same village.

Crop choice during Rabi and Kharif per ethnic group

Next we will look at the relationship between the farmers' ethnicity, culture, and crop choice (RQ2). Table 3 shows the crop cultivation pattern during Rabi season for tribal and non-tribal farmers, displayed in the absolute surface in acres and the proportion of the farmers' total surface. An important finding is that sorghum is the only crop that showed a highly significant difference in cultivation between tribal and non-tribal farmers for the absolute surface (m_T = 2.03 acres; m_{NT} = 0.6 acres, $p <$ 0.001), as well as for the proportional surface (m_T = 47.6%; m_{NT} = 12.69%, $p <$ 0.001). Additionally, the relatively high ICCs indicate that cultivating sorghum is more village-dependent than cultivating any of the other Rabi crops. Our results also show that during this season, non-tribal farmers focused more on 'cash crops' such as chickpea, maize, and rice, rather than subsistence crops like sorghum.

A closer examination of the Rabi crop choice per ethnic group gives more insights into cultivation patterns. Figure 3 shows the crop choice for each ethnic group, ranked from the most traditional tribes up to the least tribal people (i.e. non-tribal farmers): Kolam, Gond, Pradhan, Naikpod, Lambadas, and Non-tribal. Sorghum is cultivated by all people belonging to the Kolam and Pradhan tribes in our sample and by 74% of the Gond (Fig. 3a). For the people of the Kolam tribe, sorghum is the only crop grown during Rabi season (Fig. 3b). Hence, these three tribes primarily account for the differences in sorghum cultivation between tribal and non-tribal farmers, as described in Table 3. The Gond mostly focused on sorghum during this period, though some of them also grew chickpea, wheat, maize, and rice on smaller plots. The highest share of chickpea cultivation came from the Lambada tribe, followed by sorghum, maize, and wheat. The few Naikpod farmers in our group were only growing maize and rice. Compared to tribal farmers, non-tribal farmers cultivate smaller surfaces of all the mentioned crops, even though the surfaces allocated to maize and rice are superior.

The results of crop cultivation during Kharif (Supplementary Information: SI2, Table 2) point out that the tribal population mostly cultivates cotton (absolute surface: m_T = 4.4 acres; m_{NT} = 2.01 acres, p = 0.004 / proportional surface: m_T = 66.55%; m_{NT} = 23.69%, $p <$ 0.001), while non-tribal farmers cultivate rice (m_T = 11.34%; m_{NT} = 50.0%, $p <$ 0.001), in combination with important proportions of cotton and soyabean. The high ICC for rice indicates that rice cultivation was the most location-specific. Only tribal farmers grew small amounts of sorghum during Kharif, although the difference was not significant. When we compare the results of Rabi with Kharif crop cultivation, it seems that tribal farmers mostly generated their annual income during Kharif season, while they focused more on subsistence crops during Rabi. Contrastingly, non-tribal farmers cultivated cash crops during both seasons.

Table 3 Crop choice during Rabi season

Rabi crop	Absolute surface [acres]				Proportion total surface [%]			
	Tribal (N=59)	Non-tribal (N=51)	p-val	ICC	Tribal (N=59)	Non-tribal (N=51)	p-val	ICC
Sorghum	2.03 (2.26)	0.60 (1.2)	0.000***	0.44	47.60 (37.77)	12.69 (20.59)	0.000***	0.67
Chickpea	1.10 (2.57)	0.90 (1.63)	0.623	0.22	18.68 (33.09)	19.46 (28.87)	0.896	0.44
Wheat	0.57 (1.56)	0.58 (1.17)	0.968	0.21	8.43 (16.76)	12.26 (18.95)	0.268	0.28
Rice	0.41 (1.19)	0.35 (0.93)	0.791	0.42	9.50 (25.01)	19.77 (35.94)	0.090	0.38
Maize	0.37 (0.98)	0.69 (1.45)	0.194	0.17	9.18 (22.41)	24.28 (38.45)	0.016*	0.41
Vegetables	0.17 (0.56)	0.18 (0.39)	0.939	0.09	3.17 (9.99)	9.58 (22.65)	0.066	0.17
Other crop	0.14 (0.56)	0.18 (1.26)	0.831	0.01	0.48 (3.72)	0 (0)	0.321	0.01

Mean values and standard deviations (SD, in parenthesis); *: p-val<0.05; **: p-val<0.01; ***: p-val<0.001

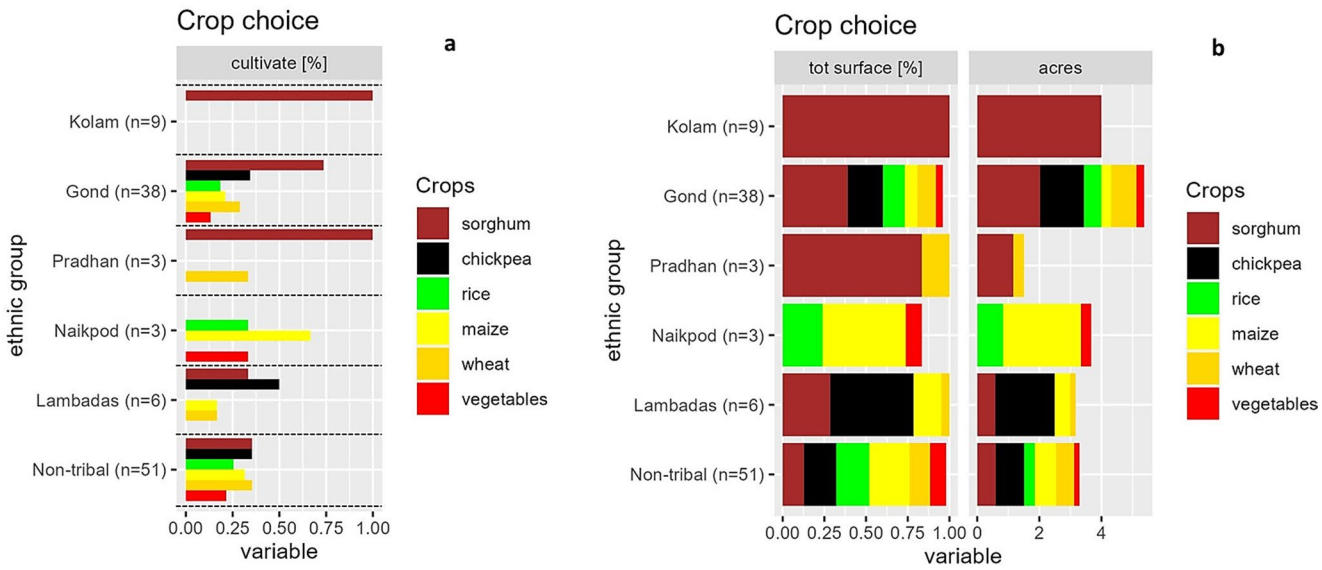

Fig. 3 Rabi crop choice per ethnic group, defined by: the percentage of people who cultivates the crop (**a**); average crop surface in acres, and the percentage of the total Rabi surface allocated to the considered crop (**b**)

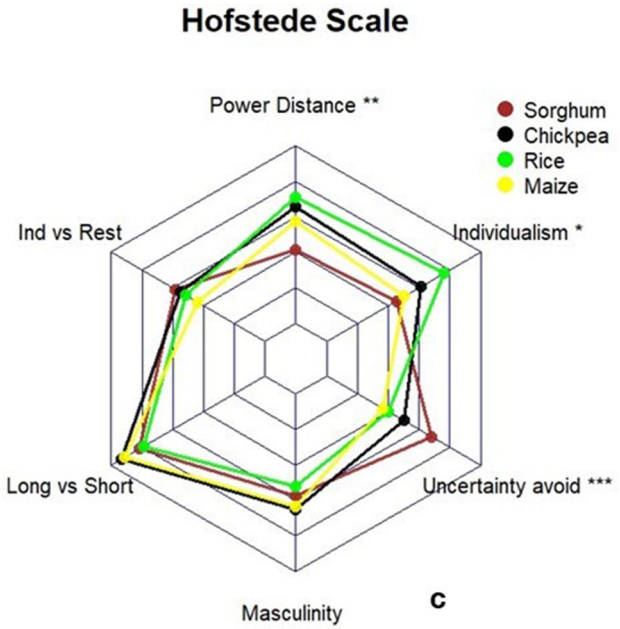

Fig. 4 Radar chart of the average score of each Hofstede cultural dimension (Power Distance, Individualism, Uncertainty Avoidance, Masculinity, Longterm vs. Short-term, and Indulgence vs. Restraint) per main Rabi crop. The stars represent the significance of the difference between the groups estimated with a t-test or an ANOVA (*: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001)

Crop choice during Rabi given cultural dimensions

When we look at the cultural values given the farmers' main Rabi crop (Fig. 4), we notice that sorghum farmers scored significantly lower on Power Distance and Individualism while they showed a higher level of Uncertainty Avoidance. Sorghum farmers mostly belong to the tribal communities, for which equality and a collectivistic nature are more important, hence the lower Power Distance and Individualism scores. Besides, their preference for tradition and 'keeping things as they are' could explain the higher level of Uncertainty Avoidance. It is also interesting to emphasize the highest score of chickpea farmers on the Masculinity dimension even though this result was not significant.

Other determinants of crop choice

In this section we will look at the influence of other determinants of crop choice, such as environment and socio-economic status of the farmers (RQ3). In our study, crop choice is defined by what the farmers in our sample selected as their main crop (sorghum (S), chickpea (C), rice (R), or maize (M)) during Rabi season, in terms of cultivated surface and general importance for their household.

Village environment

Table 4 shows the mean, standard deviation, p-value and ICC of the village environment variables for farmers who consider sorghum, chickpea, rice, or maize as their main crop. According to the data, sorghum farmers lived generally in more isolated villages than chickpea, rice, and maize farmers, further away from main roads ($m_S = 2.87$ km; $m_C = 2.68$ km; $m_R = 0.36$ km; $m_M = 0.85$ km; $p < 0.001$) and water sources ($m_S = 2.3$ km; $m_C = 1.23$ km; $m_R = 0.38$ km; $m_M = 0.59$ km; $p < 0.001$). Besides, sorghum farmers tend to live in villages with high percentages of tribal populations (~ 77%), compared to for example rice

Table 4 Village environment

	Sorghum (N=44)	Chickpea (N=27)	Rice (N=19)	Maize (N=16)	p-val	ICC
Distance to road [km]	2.87 (1.48)	2.68 (1.66)	0.36 (0.45)	0.85 (1.56)	0.000***	1
Distance to water [km]	2.3 (1.39)	1.23 (0.76)	0.38 (0.2)	0.59 (0.16)	0.000***	1
Tribe [%]	77.47 (28.74)	55.4 (24.5)	43.96 (13.71)	34.58 (9.85)	0.000***	1
Total population	1033.77 (1069.02)	1258.56 (915.53)	3638 (1303.86)	4135.56 (1360.22)	0.000***	1
Girls (age 0–6) [%]	53.03 (4.31)	48.9 (3.03)	49.73 (0.98)	49.7 (1.26)	0.000***	1

Means and standard deviations (SD, in parenthesis); *: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001

Table 5 Soil, environmental pressure, and access to technology

	Sorghum (N=44)	Chickpea (N=27)	Rice (N=19)	Maize (N=16)	p-val	ICC
Red soil [% of total land]	0.36 (0.38)	0.22 (0.32)	0.44 (0.48)	0.78 (0.31)	0.000***	0.31
Black soil [% of total land]	0.64 (0.38)	0.78 (0.32)	0.56 (0.48)	0.22 (0.31)	0.0 00***	0.31
Soil quality [1–4]	2.59 (0.82)	2.78 (1.01)	2.84 (0.9)	2.31 (0.79)	0.267	0.13
Impact drought [%]	0.11 (0.17)	0.18 (0.26)	0.18 (0.16)	0.11 (0.13)	0.369	0.03
Impact P&D [%]	0.31 (0.24)	0.28 (0.14)	0.3 (0.18)	0.3 (0.16)	0.945	0.04
Access irr. [0–2]	1.32 (0.71)	1.52 (0.58)	1.32 (0.48)	1.19 (0.66)	0.376	0.03
Access imp. var. [0–1]	0.84 (0.37)	0.93 (0.27)	0.89 (0.32)	0.94 (0.25)	0.634	0.01
Access fert. [0–1]	0.93 (0.25)	0.96 (0.19)	1 (0)	1 (0)	0.486	0.12
Access pest. [0–1]	0.89 (0.32)	1 (0)	1 (0)	0.94 (0.25)	0.144	0.16
Access tract. [0–1]	0.82 (0.39)	0.85 (0.36)	1 (0)	0.94 (0.25)	0.192	0.07
Tot. access tech. [0–6]	4.8 (1.15)	5.26 (0.71)	5.21 (0.63)	5 (0.82)	0.165	0.09

Mean values and standard deviations (SD, in parenthesis); *: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001

Table 6 Crop usage during Rabi season and expected price

Crop aspiration	Sorghum (N=44)	Chickpea (N=27)	Rice (N=19)	Maize (N=16)	p-val	ICC
Household consumption [%]	46.11 (28.68)	25.19 (20.34)	15.75 (22.1)	4.17 (9)	0.000***	0.24
Market [%]	53.89 (28.68)	74.81 (20.34)	84.25 (22.1)	95.83 (9)	0.000***	0.24
Fodder [%]	81.02 (26.83)	74.5 (29.99)	51.29 (42.91)	64.9 (41.66)	0.013*	0.12

Mean values and standard deviations (SD, in parenthesis); *: p-val < 0.05; **: p-val < 0.01; ***: p-val < 0.001

farmers (~ 35%). Sorghum and rice farmers also contrast with each other in terms of population density; sorghum farmers were generally settled in less populated villages than rice farmers (m_S = 1034 inhabitants; m_R = 4136 inhabitants; $p < 0.001$). Lastly, chickpea farmers tended to live in villages with lower percentages of girls, while sorghum farmers mostly lived in villages with a higher girl population (m_C = ~ 49% girls (age 0–6); m_S = ~ 53% girls (age 0–6); $p < 0.001$).

Soil, environmental pressure, and access to technology

Concerning environmental variables, we found significant differences in soil type between sorghum, chickpea, rice, and maize farmers (Table 5). Sorghum, chickpea, and rice farmers mostly cultivated their crops on black soil, while almost 80% of the maize farmers cultivated on red soil. As expected, the highest ICCs are found for soil type, since this characteristic is more related to a specific environment. Soil quality, impact of drought, impact of pests and diseases and access to technology (e.g. irrigation, fertilizers) did not show any differences between the different types of farmers, although the total access to technology was almost significantly lower among sorghum farmers.

Aspiration for crop utilization

The objective function describes what farmers aim to achieve with their crop. Therefore, the farmers' aspiration for utilizing their crops in a certain way will likely influence their decisions regarding which crops to cultivate. In Table 6 crop usage is defined as the percentage of total produce (all the crops a farmer cultivates during Rabi season) that is used for a certain purpose, for example household consumption or fodder. This allows us to describe the mindset of sorghum, chickpea, rice, and maize farmers regarding subsistence cultivation or market intention.

We found that sorghum farmers are significantly more likely to cultivate crops for consumption purpose, especially compared to maize farmers (m_S = ~ 46% ; m_M = ~ 4%; p<0.001). This indicates a preference of sorghum farmers to focus on subsistence during this time of the year. Besides, out of the four types of farmers, sorghum cultivators are also the most interested in producing fodder. The stover of around 81% of their total production is used to

feed their livestock, while for rice this is only 51%. In terms of cultivation for market purposes, sorghum farmers sell on average a little more than half of their produce, while these percentages are much higher for chickpea, rice, and maize farmers ($m_S = \sim 54\%$; $m_C = \sim 75\%$; $m_R = \sim 84\%$; $m_M = 96\%$; $p < 0.001$), who seem to have a stronger intention to generate income through farming during Rabi.

Demographics

The individual demographic data (Supplementary Information: SI2, Table 3) show that sorghum, chickpea, rice, and maize farmers only differed in terms of farm size. Chickpea and sorghum farmers generally owned more agricultural land than rice or maize farmers ($m_S = 6.49$ acres; $m_C = 9.11$ acres; $m_R = 3.16$ acres; $m_M = 4.25$ acres; $p < 0.05$), which can be explained by their main focus on agriculture. Rice and maize farmers more often expressed that they partly worked in other fields than agriculture, for example retail, construction, or transportation.

Discussion

Hofstede's cultural values scale: A meaningful tool to measure cultural differences in a smallholder farmer context? (RQ1)

One objective of our study was to propose a context-specific adaptation of the Hofstede Cultural Values Scale to characterize culture among farmer communities. We were able to measure potential cultural differences in a meaningful way (RQ1). Between tribal and non-tribal farmers, we observed significant differences in terms of Power Distance, Uncertainty Avoidance, as well as Individualism and Masculinity. Those results suggest that tribal people prefer a more equal and less individualistic society, compared to the non-tribal farmers, which is in line with the findings of Shah (2018). Besides, the higher Uncertainty Avoidance score observed among tribal people suggest a strong adherence to tradition and established practices, which may reduce their willingness to abandon traditional crops or experiment with unfamiliar ones. All these cultural values are in line with the descriptions of traditional Indian villages, made by Desai (1969). According to him, traditional Indian villages have developed as small, rather isolated entities with limited access to additional resources which restricts social mobility and change. This results in a low division of work and tasks between the inhabitants (low Power Distance). The isolation and reduced resources also result in the development of a local culture that tends to be stable and preserved through strong traditions (high Uncertainty Avoidance). The shared traits between people and the attachment to the local practices can also result in a strong community feeling (low Individualism).

This description of traditional villages with low specialization and a strong community feeling is confirmed by the observations of the Adilabad tribal society, made by Fürer-Haimendorf and Fürer-Haimendorf (1979). They showed that in tribal villages political and religious functions could be realized by one person, whose authority is rather weak. Besides, they observed that the creation of new villages was associated with the establishment of local cultural and religious practices, including the creation of local deities and rituals strictly followed by the community. Sorghum cultivation is the perfect illustration of a traditional practice perpetuated by the tribal communities (Pilla and Siripurapu 2021). The detection of cultural differences deeply rooted in the history of these communities as recognized by various authors supports the validity of our methodology.

The tribal farmers in our sample scored significantly lower on the Masculinity dimension than non-tribal farmers, which was mostly due to the questions regarding empathy and support. As mentioned above, tribal communities value a collectivistic lifestyle, rather than high levels of individualism and competition, which contrasts with non-tribal communities. The Masculinity dimension measures the tendency of a society to be assertive, tough, and focused on material rewards (masculine society), in opposition to a more feminine society, valuing inclusion, modesty and quality of life (Hofstede 1983), which should not be confused with a personal perception of being more feminine or masculine (Hofstede 1998; Budin et al. 2013). Interestingly, our application of the Masculinity dimension of the Hofstede Cultural Values Scale also enabled us to point out the more competitive nature of the chickpea farmers, who showed a stronger achievement-oriented attitude than the rest of the farmers. Moreover, we could show that chickpea farmers tended to live in villages with lower percentages of girls and women. This could relate to the well-identified issue of the gender gap and maybe even gender-biased sex selection, which are still major concerns in India (Sterri 2020; Jose and Sivaraman 2023). Our restricted data only allow us to make a hypothesis about the relationship between a masculine attitude and the gender gap in a part of our population. However, from a general point of view, it makes us question the possibility of a contradiction between economic objectives like market orientation, which is associated with higher levels of competitiveness, and the pursuit of other societal objectives like increasing gender inclusiveness, which might request an opposite attitude. For example, Sterri (2020) states that women can still be seen as an economic cost because of the dowry system (where the bride's family pays the groom's) that still persists in most of rural India.

Our adaptation of the Hofstede Cultural Values Scale could potentially draw attention to this highly relevant socio-cultural phenomenon. Lastly, when we compared the cultural value scores of men and women, we found that Masculinity was the only dimension on which the two groups showed significantly different results. These findings are consistent with what Hofstede describes in his book 'Masculinity and Femininity'; the Masculinity dimension of his model is the only one that consistently produces different scores for female and male respondents (Hofstede 1998).

A possible limitation of using Hofstede's dimensions to identify differences in cultural values between groups of farmers is that the original framework was created to measure national cultural differences (Hofstede 1983). It therefore assumes cultural uniformity within national borders. Some critics consider equating 'culture' to 'nation' problematic (Signorini et al. 2009). We applied this methodology to a very small proportion of India, claiming the possibility to detect differences in cultural values, due to the high ethnic, cultural, environmental, and demographic variations within the district. Even though the results of the Hofstede questions seem meaningful and match the literature concerning these farmer groups, using concepts like individualism vs. collectivism may oversimplify complex relationships such as kinship structures or seed-sharing networks. Nevertheless, future research could test the validity of the approach with other populations and crops, thereby expanding the scope of culturally-sensitive agricultural research.

The role of ethnicity and culture in crop choice (RQ2)

Next, we will look at the relationship between ethnicity, culture, and crop choice (RQ2). An important finding of our study is that, among all the main Rabi crops cultivated by the farmers in our sample, sorghum is the only crop for which both the absolute area cultivated and its share of the total cultivated area differ significantly between tribal and non-tribal people, as well as between different tribal groups. The fact that sorghum farmers showed the highest level of Uncertainty Avoidance, supports the hypothesis of a cultural attachment to this crop, which was also confirmed during the focus group discussions. This highlights the special status of sorghum as a traditional tribal crop and the strong connection with the ethnicity and culture of the farmers that keep sorghum cultivation alive. The importance of sorghum as a nutritious food for both humans and animals was mentioned during the focus group discussions. According to the farmers sorghum is "satisfying for the stomach" and "healthy". Many generations in these communities grew up eating and cultivating sorghum. Additionally, they agreed to sorghum stover being the "highest quality type of animal feed", compared to other available options. Gond and Kolam farmers also expressed that sorghum played a prominent role in their tribal culture and traditions. Not only are the sorghum grains used to cook their main dishes, such as *roti*s (Indian flat breads) and *khichdi* (thick porridge), the crop is also used to worship the gods and to protect the community from evil spirits (Fürer-Haimendorf and Fürer-Haimendorf 1979; Pilla and Siripurapu 2021). These features were identified by the farmers as reasons to continue sorghum cultivation, despite the lower profitability of this crop. Likewise, a study by Pandravada et al. (2013) shows the attachment of different tribal groups to sorghum as a subsistence crop and Labeyrie et al. (2014) describe how different ethnic groups in Kenya interact in shaping sorghum seed exchange networks in a culturally diverse area.

Ultimately, we could consider that the synthesis of agronomic, socio-economic, and cultural data coming from our survey constitutes a basis for defining broader categories of farmers, similar to the notion of 'farming' styles developed by Van der Ploeg (2008), which emphasizes the importance of culture: "Farming styles refers to a cultural repertoire, a composite of normative and strategic ideas about how farming should be done" (Van der Ploeg 1993, p. 241). Van der Ploeg defines farming styles in terms of norms, praxis, market, and context, and we can apply these broader categories to the farmers in Adilabad. On the one hand, we observe farmers living in more rural and secluded areas (context), cultivating a subsistence crop like sorghum (praxis), which is mostly used for consumption and informal markets (market). This group is characterized by distinct ethnic and cultural traits (norms) that influence their perspectives regarding innovation (Uncertainty Avoidance) and their relationship with government authority (Power Distance). On the other hand, farmers living in more urbanized areas tend to cultivate cash crops for sale on formal markets, with potentially more individualistic and competitive tendencies, as reflected in the Individualism and Masculinity dimensions. However, while it can be useful to describe farming groups using more conceptual categories to facilitate understanding and comparison, we should be cautious not to over-homogenize the farmers within those categories, as their reality is often more complex (Vanclay et al. 2006). For example, the fact that the Adilabad farmers cultivate multiple crops between the rainy and post-rainy season, creates some overlap between categories. This is best illustrated by the sorghum farmers, who prioritize a traditional subsistence crop during the post-rainy season, while cultivating cotton – a cash crop with a highly structured value chain connected to the Indian textile industry (Blaise and Kranthi 2019) – during the rainy season.

The role of other determinants in crop choice (RQ3)

Crop choice patterns tied to the farmers' ethnic and cultural background, particularly for sorghum, require consideration of environmental drivers. Indeed, the high ICC values show that for both seasons, cultivation of each crop is closely related to the location and therefore, the local environmental conditions, such as the distance to roads and water sources. This is especially the case for Rabi sorghum. The fact that sorghum farmers are mostly located in more isolated and less populated villages, situated in hilly areas strongly contrasts with cash crop (rice, maize) farmers, who are located in plains closer to urban areas. Black soil was also associated with chickpea cultivation. These results are consistent with the agronomy and value chain of the studied crops and show that crop choice is above all constrained by biophysical conditions. As mentioned earlier, access to technology tended to be lower among sorghum farmers, which could be related to the policies initiated at the time of the Green Revolution that aimed at increasing technological inputs for farmers cultivating commercial crops (Pingali 2012; Hazell 2009). Compared to rice and maize, sorghum is more tolerant to harsh environments and low input conditions present in the isolated hilly villages where tribal farmers live. The subsistence nature of sorghum also explains its ability to survive with low connections to the market and value chain facilities. In Adilabad, sorghum is essentially consumed by the producer and/or locally traded (Nagaraj et al. 2013). On the other hand, rice and maize production requests more input, especially in terms of irrigation and pest and disease control. The commercially-focused nature of those crops also requires that the farmers are connected to the market, which is easier in villages closer to cities where trade takes place. Despite the sorghum farmers' strong focus on subsistence, several focus group participants reported that sorghum cultivation has recently begun to receive increased government support. In one village, farmers mentioned that for the past one to two years, they have been receiving a minimum support price of 2,500 INR per quintal, which has generated a growing interest among them in selling their sorghum grain on the formal market. The minimum support price is most likely connected to policies initiated by the Government of Telangana in 2019, such as the Special Nutrition Program and Integrated Child Development Services (mid-day meals).

The relative importance of culture and ethnicity with respect to other determinants of crop choice (RQ4)

Our findings raise the question of the respective influence between the biophysical variables composing a certain environment, the farmers' ethnicity, and their culture. Do people develop a certain culture and crop choice because they are in a specific environment? Or do likeminded people gather in a certain environment because the location meets their lifestyle and needs? By emphasizing the geographic variability (11 locations) in order to cover the four different cropping systems rather than the within village household variability, our data make it difficult to distinguish the relative influence of the environment, the ethnic, and the cultural backgrounds. The fact that the populations in the selected villages were rather homogeneous in terms of language, ethnicity, or even culture, as observed in the ICC results, complicates the implementation of statistical methods to isolate the respective influence of those variables with respect to the environment. The relative ethnic and cultural homogeneity support the hypothesis of natural conditions being causal for the development of certain types of populations and associated socio-economic and cultural practices. The ethnic and cultural homogeneity associated with a particular environment could result in group influence concerning crop choice, as observed by Labeyrie et al. (2014).

An interesting comment during one of the focus groups illustrates what can happen when farmers are given the opportunity to change their cultivation patterns due to certain policies. One tribal village was located close to the main road and nearby a more urban area. Most farmers originally cultivated sorghum, but were offered support to install irrigation facilities, so they could switch to rice cultivation. After making this change and abandoning sorghum, these farmers expressed regret towards their choice and were considering taking up sorghum cultivation again, since it was an important part of their culture. Moreover, long periods of drought made them prone to switching back to their traditional and more resistant crop.

Alternatively, a common culture and preference for a certain crop could make people move to a certain environment. An example of this is the Kolam tribe in our sample. They came originally from a neighborhood village, but gathered over time in a nearby, more spacious area where they continued to cultivate sorghum. Similar stories are described by Fürer-Haimendorf and Fürer-Haimendorf (1979), where Gond tribes created new settlements with their own local culture and deities. Additionally, we could see in our data that some tribal people (2 Gond, 2 Pradhan) who lived as a minority in a village with predominantly non-tribal people, continued to grow sorghum when the majority of their peers cultivated other crops. Those few cases can illustrate a tendency of tribal farmers holding on to their traditional crop, independent of the environment. This suggests that the association between certain cultural dimensions and crop choice that we document may represent a causal relationship. Further research is necessary to verify this conjecture.

Conclusion

This study contributes to broader scholarly discussions on participatory breeding, technological innovation, and agricultural decision-making. By adapting the Hofstede's Cultural Values Scale to detect differences between farmer groups (RQ1), we offer a novel lens for understanding how cultural values shape the farmers' preferences, especially crop choice (RQ2). Future research could assess the validity of this approach across different populations and crops, contributing to a broader understanding of culture in agricultural research. Additionally, our study underscores that, even though environmental conditions are important drivers for crop choice, culture matters too (RQ3/RQ4). Despite certain limitations of Hofstede's framework, such as its potential to oversimplify the complexity and dynamism of cultural values, and gender-based differences in scores on the Masculinity dimension, our findings indicate that it remains a valuable tool for identifying cultural differences within smallholder farming communities. This has implications for the development of more context-sensitive agricultural interventions. Participatory breeding should prioritize developing and offering crops and varieties that align with the farmers' cultural values, preferences and intended use. By recognizing that different ethnic groups have unique cultural norms and values that influence their decisions regarding crop cultivation, breeders can create more effective and targeted breeding strategies that resonate with the communities they intent to support.

Moreover, our findings suggest that there is a need for a more nuanced approach to agricultural extension programs. Rather than trying to provide farmers with 'modern' or 'superior' varieties that do not necessarily meet their needs or expectations, extension programs should focus on better aligning their outreach strategies with the values and preferences of different farmer groups. This could include targeting specific groups with varieties that match their cultural values, such as collectivism or a tendency to avoid uncertainty. Avoiding the promotion of new crops or varieties that do not resonate with the farmers could also be more effective, efficient and respectful to the cultural context of the farmers. Undoubtedly, to be able to accomplish this, breeders and farmers of different ethnic (tribal) groups should actively collaborate to ensure that the farmers' contexts and valuable knowledge are used as a guideline for the development and evaluation of new crop varieties. Overall, the insights from our study highlight that understanding culture is not merely a supplementary consideration, but rather a crucial element in designing breeding and extension strategies. Designing culturally-sensitive and more inclusive interventions could therefore lead to meaningful and sustainable adoption of new crop varieties.

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Author contributions Conceptualization: Marijn Voorhaar, Vincent Garin; Methodology: Marijn Voorhaar, Vincent Garin; Data collection: Marijn Voorhaar, Vincent Garin, Vittal Rao Kumra; Formal analysis and investigation: Marijn Voorhaar, Vincent Garin; Writing - original draft preparation: Marijn Voorhaar, Vincent Garin; Writing - review and editing: Marijn Voorhaar, Vincent Garin; Funding acquisition: Jana Kholová; Resources: Jana Kholová, Vittal Rao Kumra; Supervision: Erwin Bulte, Robert Lensink, Jana Kholová, Vittal Rao Kumra.

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Data availability The data generated during this study, as well as the R script created for data analysis to produce the results, are available under the following repository: Voorhaar, Marijn, 2025, "Culture, ethnicity, and crop choice: insights from tribal and non-tribal farmers in Adilabad District, India", https://doi.org/10.7910/DVN/DILUT4, Harvard Dataverse.

Declarations

Ethical approval This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki. Prior to beginning the research activities, ethics approval was obtained from the Institution Ethics Committee (IEC) ICRISAT and the Integrated Tribal Development Agency (ITDA – Utnoor, Adilabad). Verbal informed consent was obtained from each participant before an interview was taken and they were informed of their right to withdraw from the study at any time. Data was treated confidentially and anonymously.

Competing interests The authors declare no competing interests.

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Marijn Voorhaar is a PhD candidate at the Development Economics Group (DEC) at Wageningen University & Research (WUR), in partnership with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Patancheru, India. She has 7 years of experience in research concerning vulnerable populations and social inclusion in developing countries. The last 5 years she has focused on smallholder farmers belonging to tribal communities in India.

Vittal Rao Kumra is the project manager of the Centre for Collective Development (CCD) in Utnoor, India. He and his team lead initiatives to strengthen tribal cooperatives and develop sustainable value chains. His work focuses on supporting small and marginal farmers through access to finance, market linkages, and capacity building, with the main goal of improving livelihoods and ensuring long-term sustainability.

Jana Kholová is a scientist at ICRISAT, India, and the Czech University of Life Sciences in Prague. She specializes in environment-adaptive traits, high-throughput phenotyping, crop system modelling, ICT, and agri-system digitalization. Better alignment of agricultural technologies with the ethno-socio-bio-geo-physical context of farming regions is an important focus of her research.

Vincent Garin is a biostatistician working at CIRAD, specializing in plant genetics and breeding, with a strong interest in participatory approaches and the development of technologies for smallholder farmers.