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Reshapping agriculture technology adoption thinking: Malthus, Borlaug and Ghana's fail green revolution

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ABSTRACT

Previous research on green revolution established the effect of farmers' socio-economics characteristics on technology adoption; however, the impact of culture and religion is unclear. This research collected data through a survey from January to April 2019. Participants were rice farmers from three ethnic groups (Mole-Dagbani, Gurma and Guan) and three religious' denominations (Christianity, Islam and Christianity). After analysing the data to identify critical societal values affecting the adoption of improved rice varieties, we realised that our results appropriately explained Prospect theory. We find that cultural and religious values significantly influence rice farmers' adoption decisions. Christian faith has a positive relationship with the adoption of improved rice seeds, while the Islamic religion has a negative connection. The fact that culture and religion affect adoption suggest agriculture technology societal standard integration. Based on the findings, we recommend the all-inclusive approach in the diffusion of agricultural technology.

1. Introduction

It is a sad fact that on this earth at this late date, there are still two worlds, 'the privileged world' and 'the forgotten world'. The privileged world consists of affluent, developed nations, comprising twenty-five to thirty per cent of the world population. Most people live in luxury never before experienced by a man outside the Garden of Eden. The forgotten world is made up primarily of developing nations, where most people, comprising more than fifty per cent of the world population, live in poverty, with hunger as a constant companion and fear of famine a continual menace.[1]

The debate linking food, population and economic growth is not new. While Adam [1]; Book 1, Chapter 8, Part 23) observed that "the most decisive mark of the prosperity of any country is the increase in the number of its inhabitants," [2] countered by saying that there was a direct limit on the size of a population in an agrarian society, such that food production needed to increase proportionally with population otherwise it would only produce misery or vice [2]. This was a temporally solved advent of the industrial revolution

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[1] Norman Borlaug (1970) Nobel Peace Prize Lecture, The Green Revolution, Peace, and Humanity – available from https://www.nobelprize.org/prizes/peace/1970/borlaug/lecture/.

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(approx. 1760–1820), where technological advances decoupled the Malthusian relationship between population and sustenance as the limits of production and population multiplied. Economic theory also diverged from Malthus due to the relatively unattractive implication that there is a positive relationship between fertility rates and levels of per capita income [3]; p. 498).[2] [4,4], This led to economic growth theories that held economic growth was not a function of population growth but of specialisation and trade; in fact [5], were so certain they argued that when income was measured '*correctly*', the true positive relationship would emerge even if the current empirical evidence proved otherwise. As a result, the Malthusian linkage between food production and population mostly became a dusty relic of economic history. However, the multiplier effect granted by the industrial revolution on food production was eventually reached, but the population continued to expand, and Malthus' prediction of misery or vice became evident. Norman Borlaug, hailed as the 'Father of the Green Revolution' echoed the words of Malthus during his Nobel Prize lecture[3] stating "Civilization as it is known today could not have evolved, nor can it survive, without an adequate food supply. Yet food is something that is taken for granted by most world leaders even though more than half of the world's population is hungry. A man seems to insist on ignoring the lessons available from history" [6].

This lesson is being experienced by many African nations, e.g. nations like Ghana where the adoption of greater yield variants of rice is critically low, estimated to be 60% [7], even though rice is one of the primary staples. Demonstrating its importance, the Government of Ghana spends over $1.1 billion US dollars annually importing 70% of the national rice consumption [8]. In line with Malthus, Ghana has become a net importer of rice because the increase in consumption (population) has superseded its agricultural productivity, but the real question is why? Borlaug's Green Revolution demonstrated that much like the Industrial Revolution, the multiplier effect in food production through the adoption of specialised crop variants could feed a much larger population. However, while Northern Ghana is the leading producer of rice in Ghana, it has the lowest average yield compared to the rest of the other ecological zones [9].

The development of the rice sector is a significant concern to the Government of Ghana, while it is the country's most consumed cereal crop up to 70% of rice consumption comes from imports. Furthermore, the contribution of domestic production to total rice consumption significantly decreased by 11% between 2014 and 2016 [10]; p. 14). As a result, the aim of self-sufficiency in rice production by 2018 was not achievable. While the non-adoption of improved seed has as the reason for this failure, it is Northern Ghana that has been singled out as the major contributor [11–15]. Reports indicate that the national adoption rates of new certified seed types are about 67%, but in Northern Ghana, only about 32% of farmers have followed suit [9].[4] [16,16], Furthermore, average national rice yields are calculated to be 4.45 tons/hectare, but in Northern Ghana, this drops to 2.5 tons/hectare [7]. Differences in climatic condition are not considered a reason for the significant gap in adoption or yields between Southern Ghana and Northern Ghana as hybrid rice is adaptive to climate change and most improved rice varieties are disease resistant [17,18].

Furthermore, the region has the lowest rate of improved rice variety adoption in the country which means that it has the potential to increase rice yields which would greatly reduce the incidence of poverty in the region (Ghana Statistical Service, 2010).[5] Some researchers have argued that farmers perceive the adoption of new crop varieties as a decision dilemma. Specifically, weighing the benefits of adopting the new rice varieties and the potential loss of cultural and religious values from switching from historically significant practices [19–21]). The asymmetric nature of gains and losses in a decision is very close to that described in Prospect Theory (Kahneman and Tversky, 1979).

Based on previous investigation, the critical factors that affect farmers adoption of improved rice verities are socio-economic variables with limited or unclear relationship between culture and religion and adoption of improved rice varieties. Thus, this paper aims to investigate the impact that cultural, religious and social factors have on the decision-making processes of farmers in northern Ghana regarding the adoption of new rice varieties. The key question is whether or not we can explain the outcomes via the lens of Prospect Theory. The remainder of the paper is as follows: Section 1 discusses the historical and theoretical background, Section 2 details the method and the data of our study, Section 3 presents the results and Section 4 concludes.

2. Literature

The successive failure of the green revolution in Northern Ghana has been blamed on farmers' non-adoption of new crop varieties [11,22–24]. However, thus far research has only explored the socio-economic and demographic characteristics of farmers while mostly ignoring the impact of social norms such as religion and culture on influencing the adoption of technology such as new crop varieties. In Ghana, culture and religion are critical in agricultural technology diffusion. Peer effects from clan membership or religious groupings were likely to influence the adoption of improved crop varieties [25,26]. We observe that Northern Ghana has the highest variation of different cultural and religious groups in the country, which include the Mole-Dagbani, Gurma and Guan cultures which

[2] The traditional neo-classical models of economic growth had no place for the emergence of technology change such as the industrial or green revolutions. However, the new endogenous growth models (so-called "AK" models) included technology as well as the traditional land, labor and capital (see Ref. [4].

[3] Norman Borlaug's genetic development of disease resistant high yield dwarf wheat delivered yields greater than was ever thought possible, for which he was awarded the 1970 Nobel Peace Prize for his green revolution which fed the starving masses in India and Pakistan and saved more than an estimated 1 billion lives.

[4] This is supported by Ref. [16] who showed that more than 60% of farmers in Northern Ghana continue to depend on unimproved seed for production compared to only 27% of their counterparts in Southern Ghana.

[5] Northern Ghana is ranked the poorest in the country with 4.6% of the urban population and 27.3% of the rural population living in poverty.

overlap with the Christians, Moslems and Traditional religious denominations. We observe the large variation of religious and cultural identities in Northern Ghana, but to understand its role in decision making we need to explore the role of social norms in society, their impact on decision making and how Prospect Theory may account for the outcomes.

2.1. Social norms, culture and religion

Our actions, behaviour and choices are a direct result of factors such as moral and social norms [27], religious and political ideology [28] or social identity (Akerlof & Kranton, 200X). While they begin as a set of loose common beliefs, over time that set shared beliefs (social norms) are institutionalised (Frank, Meyer and Miyahara, 1995) to become the set of rules that governs behaviour and social interactions for members of that society. These rules are otherwise known as social norms [27,29] and set the acceptable forms of behaviour and attitudes under which the group or society functions. These norms guide individual actions and behaviour and "specify what actions are regarded by a set of persons as proper or correct, or improper and incorrect" (Coleman, 1990: p.243), forming the social fabric as well as providing the moral and ethical compass with which to navigate a societal existence (Cialdini and Trost, 1998). 'Correct' behaviour was self-enforced by the members of that society to maintain the societal structure [30], behavioural enforcement achieved through either the coercion or shaming of individuals into the required action [31]. Generally, social norms have no legal or formal basis and may sometimes even conflict with laws (Coleman, 1990: 243). Still, the threat of group exclusion means that rational actors consider them when determining the costs and benefits of exercising choices (Coleman, 1987: 135).

Some norms are like conventions, except that it is not clear that any ulterior purpose is being served, e.g. norms of dress, etiquette and dietary rules fall into this category. Other social norms take the form of codes of honour, e.g. societal rules of vengeance, ritual suicide or bribery [32]. Alternatively, they can resolve coordination problems, such as prescribing that one should drive on a particular side of the road. Social norms survive over several generations bypassing the norms on to new members through socialisation (Goldthorpe, 1998; Long and Hadden, 1985). Bypassing on the norms of that society they perpetuate and strengthen them (Foucault, 1979; Caudill, 1973; Frank, 1995) and when enforced on new members they have a significant impact on values and beliefs (Inkeles, 1969). Most individuals are immersed in society's social norms, codes of behaviour and expectations throughout their life (Foucault, 1979), but predominately during the formative years of youth. This passing of social norms is true for all societies, large and small, including all subsets or sub-cultures. Once norms identified as being shared by other members of society, they cannot be easily disregarded. Social norms also facilitate a group herd mentality, i.e. once members of society observed conforming to a social norm, other members will follow (Banerjee, 1992). An analogy used by Ref. [33] likened the adherence to norms to be like the use of a taxi, individuals cannot embark or disembark at will, for to do so would be deemed irrational. Individuals will follow the prescripts of a social norm even if it is not in their best interest to do so [32,33], especially if the punishment for breaching norms is severe enough (shunning, ostracisation, or physical punishment).

Religion, culture and ethnicity are often difficult to separate, such that it is difficult to determine where one ends, and another begins. Furthermore, culture and ethnicity are often used interchangeably, as ethnicity usually refers to groups that stemmed from national, regional or community locales, but culture may not be geographically dependent [34]. Culture is often defined by a geographical boundary, language, customs and tradition [35], it includes the customs, beliefs, foods, arts, language, morals and laws that bind peoples together, creating in and out-group differences that are often obvious to casual observation. Whereas ethnicity extends from an individual's identity and position in that group usually attained through birth or family ties, and like cultural identity, ethnicity is highly homogenous between members of any specific ethnic group [36]. Given that social norms equally derived from culture, ethnicity and religion, there is usually little significant difference between group norms, individual's social attitudes and cultural beliefs [37].

Just like all other social norms, religious norms are the rules and regulations designed as belief and practices for a common sacred thing called God or gods to unify members in the moral community of Church, Mosque or Deity [29]. Furthermore, the practices and beliefs are accepted and forbidden to those who agree to be part of the society using rituals, spirit or myth [38]. Not only do individuals need to be concerned about punishment and reward from their community but also that of divine retribution, this means that even when unobserved or unenforced religious norms often internalised and followed automatically. The participation of women in the economy can differ greatly between societies based on culture and religion. For example, some cultures viewed the shift from using women's labour in harvesting crops to adopting machines/technology as an undermining of cultural practice. As such these societies used social norms to disapprove of technological change to maintain traditional practice [39,40], in this way social disapproval (and possible social exclusions) influence adoption or non-adoption [41].

Research has demonstrated that social norms impact the adoption of new technologies in other agrarian groups [42]; p. 225) in Asian and Africa [43]. noted that while the effort to promote agricultural technology in sub-Sahara Africa remains high, the technology adoption rate is minimal. Adopting fertiliser in Ethiopia is affected by ethnicity and religion such that a homogeneous cultural milieu promoted adoption, but heterogeneous religious factions decelerated the diffusion [44]. This was supported by Ref. [45]; who concluded that religion plays a critical role in pro-agrarian development projects in Eastern Ghana [25]. indicated the need to balance farmers' religious and cultural traditions with the perceived risk and anticipated benefits of technology adoption if technological adoption was going to be successful. Since social norms are the expectations and beliefs of that specific social group, there expected to be very little in-group variation [46,47]. As such, we would expect that where farmers exposed to normative social behaviours that limit or reject changes in farming practices or the adoption of new rice variations, the adoption rates are going to be significantly lower.

2.2. Decision making and prospect theory

Decision-making is the core of both micro and behavioural economics, as individuals must make choices regarding the options available. Beginning with Bernoulli's (1738) simple expected value decision theory, it extended into expected utility theory [48], which included risk aversion and the axioms of rational choice [49,50]. Kahneman and Tversky's (1979) Prospect Theory (PT) rejected what described as the "Bernoulli error" (see Ref. [51], which was the assumption that the absolute level of wealth was the carrier of utility. PT posited that the carrier of utility is the changes in wealth relative to a particular reference point, as such individuals are likely to adopt a more risk-averse behaviour when faced with choices involving gains but become more risk-seeking when faced with choices involving losses. This "reflection effect" is modelled by a utility function that exhibits differing curvature for gains (concave = risk aversion) and losses (convex = risk-seeking).

Prospect theory works on utility in the same way as for wealth. It has been used several times to explore decision-making under risk in diverse environments such as migration, finance and disasters. For example, prospect theory has been used to analyse the migration decisions; the findings show that people with less risk-averse seek opportunity elsewhere by migrating while people with high risk-averse will not be willing to move [52]. Prospect theory was used to explain the selection of financial portfolios and showed that loss-averse investors are willing to take a risk-based on the performance evaluation [53].

3. Cultural factors

A society that largely depends on the permission of gods and the requirement to seek their consultation before making decisions will likely not adopt new ideas or technologies. While consulting the gods is a common ethnic practice among the peoples in Northern Ghana, which involves seeking the permission of the gods before making a decision, the number of times that the gods consulted varied from ethnic groupings and communities. As such, the more frequent the need for consultations, the less likely farmers would adopt technology as it would be viewed as moving away from the traditional beliefs and views. Furthermore, in some ethnic groups it is taboo for farmers to attend to their farming activities on some days in a week, e.g. Mondays, Thursday and Fridays are reserved days for some ethnic groups (Mole-Dabani, Gurma and Guan). The cultural norm is that individuals undertaking farming activities on those days are not blessed and may experience low yield as punishment [54]. This is in direct conflict with modern technology which emphasised frequent visit to the farm and that farmers would not attend technology sensitisation training programmes on those days. Such ethnic practices could significantly impact an individual's decision to change to new practices or even learn about them, negatively affect the adoption of improved rice varieties.

In many Ghanaian societies, Chiefs are powerful people who have direct control over their subordinates and can impose sanctions on who behave contrary to their rules and regulations. Even though individual farmers may see the benefit in adopting new technology they are not likely to do so without the approval of the chief, therefore having the chief adopting or supporting the use of new technologies would significantly improve the adoption rates of improved rice varieties [54,55]. The final cultural aspect is that of the Ancestors, who lived in the past and have an understanding of the past and present condition of the land that the farmers are cultivating. Farmers need to consult[6] with the ancestors before adopting new agricultural technology as they believe that the traditional rice varieties belong to the ancestors. Without approval, it may anger or be seen as an abandonment of the forefathers. Given the reverence many groups place on those that came before, it is likely that changes or adoption of new technologies will be avoided to minimise social disapproval and possible punishment.

4. Religious factors

Regardless of the benefits associated with agriculture and technology adoption, committed members of the various faith will not sacrifice their time to farming activities. Similar to the cultural norms some days are restricted due to religious beliefs in various regions of Northern Ghana, for example, Thursday, Friday, Saturday and Sunday are used as religious observances (spiritual days) and as such must be free of any activity including farming. An additional similarity is the role of the religious leaders to the chiefs; this includes pastors, imams and priests, who greatly influence their followers [56]. There has been a split on the religious acceptance of new technologies and rice varieties, specifically that of Genetically Modified Food (GMO) crops. Some religious leaders asserted that the technology had the approval of God, and as a result, the followers of those religions were likely to adopt genetically modified crops [57]. However, some Islamic leaders and Muslim groups disagreed in consuming GMF crops; as a result, the leaders discouraged followers from adopting the technology and banned its importation. As such, we would expect that there would be a significant amount of diversity between religious groups in the adoption of rice varieties.

Another potential factor impacting the decision process is the belief in destiny, where an individual believes that an event will occur regardless of human intervention. There is a strong connection between many religious faiths and an individual's future outcome, whether it be doom, bright or fortune. As such those with such beliefs are less likely to adopt new agricultural technology as nothing, they can do will change the outcomes (for example crop yields) if it is their destiny. This is closely related to the religious belief of

[6] Farmers get approval from their dead ancestors through the pouring of water and milk into a grave and await a dream revelation before making any decisions.

receiving a blessing from God, where a faithful farmer, regardless of the seed grown, farmers who are blessed to have a bumper harvest experience the right combination of the natural factors from God.[7] Alternatively, those who experienced poor yield are perceived to have received it as a punishment from God for their lack of faith. Such beliefs would negatively impact the adoption of improved seed, for as is the case in destiny adoption plays no part in the production or output.

The cultural and religious impacts on adopting new technologies create a decision dilemma for the farmers. On the one hand, farmers could accept improved rice varieties and gain significant benefits, such as higher yield, shorter maturity period, resistance to pests and disease and more. On the other hand, if a farmer adopts the improved rice varieties, they will gain the benefits. Still, they will face potential social and religious sanctions for breaking cultural and religious values. The farmer then needs to weigh the loss of cultural or religious utility versus the gains in food, income and prosperity. A situation that closely follows the prospect theory arguments, where an individual overweighs the losses compared to the gains.

5. Data and method

In this paper, we use field survey data collected from farmers in Northern Ghana to explore the impact of cultural and religious variation on the willingness to adopting improved rice varieties. Farmers recruited via the extension officers in three of the five regions who assisted the researchers in identifying potential respondents and organised appropriate meeting times and locations for the survey to be administered. Northern Ghana, like many regions in sub-Saharan Africa, have complex mix of religions, cultures and ethnicities where it is dominated by Muslims (50.4%), followed by Christians at (27.8) and Traditionalists (21.8%); and three significant ethnic groups in Northern Ghana regions which include the Mole-Dagbani (41.4%), the Gurma (25.2%) and the Guan (33.4%) of the regional population [58]. Rice farmers from the region were selected to ensure a representative sample of religions and ethnicities. The numbers selected in each community were proportional to the religious and cultural population (See Fig. 1). Farmers in the various religions and ethnicities are selected using simple random sampling technique.

To maintain statistical inference, we ensured that a minimum sample size of 30 was maintained for all subgroups while maintaining representative proportions. In total, 464 rice farmers participated in the field survey, which was made up of the following participants Mole-Dagbani (192), Gurma (117) and Guan (155) participants. Furthermore, the data sample has the following religious representation: Muslims (234), Christians (129) and Traditionalists (101), see Table 1.

The primary variable of interest in this study was the adoption of new technologies (i.e. improved rice varieties) which recorded as a binary with one denoting the decision to adopt and zero otherwise. Hence, we estimate probit using adoption as the dependent variable and socio-economic, cultural and religious norms as independent variables (see Table 10). We have adopted the [59] measures

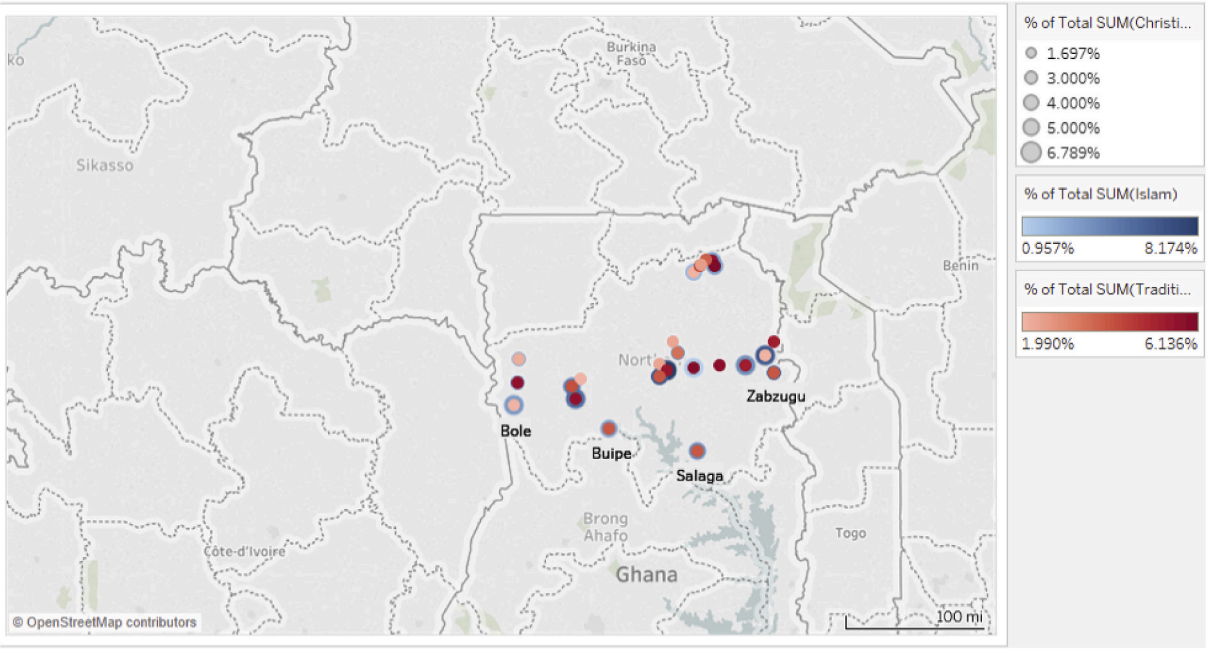

Fig. 1. Map of Ghana showing selected communities in Northern Ghana for the 2019 survey.

[7] Many farmers in Northern Ghana rely on rain and sunshine for growing of crops and do not use irrigation and other modern technology, but rely on the bounty of their faith in God.

Table 1
Cross-tabulation of ethnicity by religion.

Ethnicity	Religion			
	Christianity	Islam	Traditional	Total
Mole-Dagbani	48	111	33	192
Gurma	33	50	34	117
Guan	48	73	34	155
Total	129	234	101	464

Note: This table provides the number of rice farmers across the ethnic and religious group that participated in the 2019 survey.

Table 2
Description of variables.

Variable	Obs.	Mean	SD	Min	Max
Age (years)	464	32.450	2.100	23	56
Male	464	1.012	0.342	0	1
Household Size	464	3.664	1.072	1	7
Married	464	1.363	0.134	0	1
Education (years)	464	4.102	1.277	0	12
Expenditure (GH)	464	25.120	3.125	12	42
Primary Occupation	464	1.256	0.121	0	1
Experience (years)	464	8.548	2.663	4	16
Farming System	464	1.326	0.246	0	1
The extension (access)	464	1.635	0.463	0	1
Credit Access	464	1.024	0.855	0	1
Consult Ancestors	464	3.640	0.015	0	6
Farming Restrictions (cul)	464	2.100	1.028	0	7
Chief Permission	464	3.127	0.231	1	5
Ancestors Permission	464	2.008	1.289	1	5
Farming Restrictions (rel)	464	3.651	0.135	0	6
Religious Permission	464	2.769	0.214	1	5
Fixed Destiny	464	3.102	1.003	1	5
God Blessing	464	2.868	0.235	1	5

for the cultural and religious practices enacted as social norms for our surveys in Northern Ghana and included questions on farmers' attitudes on technology adoption. For example: ascertaining how much farmers associate with statements such as "*How can it be better than our way*?" and "*We know what is best for us.*" Furthermore, we included four cultural and four religious-based variables to capture the possible impact of either on farming practices. The cultural variables included: C*onsultation of Gods; Restriction of Farming Days* (culture); *Chief Permission* and A*ncestor Permission;* and the religious variables: *Religious Leader Approval; Restriction of Farming Days* (religion); *Destiny* and *God Blessing*. Additionally, we collected a range of demographic data including *Age*; *Gender*; *Household Size*; *Married* Status; *Education*; farming *Experience*; annual *Income*; *Off-Farm Activities* (work); access to *Extension*; *Credit Access*; and use of *Farming System*. The variables, their description, unit of measurement and a priori expected sign are shown in Table 10. Also, the variables mean, standard deviation, minimum and maximum are presented in Table 2.

The social norms variables are defined as follows: Consultation of gods are in number of times, religious restriction and cultural restrictions are in numbers of day in a month, and the rest of the variables are as follows: 1 for strongly disagreed, 2 for disagree, 3 for indifferent, 4 for agreed and 5 for strong agreed.

6. Analysis

This paper aimed to explore farmers decisions to adopt or not adopt improved rice varieties in Northern Ghana, specifically if the cultural or religious social norms are responsible for outweighing the benefits of adoption. As such, we estimate the likelihood of adoption based on the dissatisfaction (disapproval) generated via social norms versus the benefit of adoption form increased rice output and income. The data were first analysed using a Kruskal-Wallis test to determine if there were differences in the main focus variables across ethnic and religious groups (see Table 5), a Spearman's Rank Correlation test (see Table 4) was employed to check the relationships between variables. Finally, as the *adoption* variable is binary, we used hierarchical probit regression, meaning that we could not directly interpret the coefficients, as such, we used partial derives to estimate the effect sizes. We could compare the potential disutility or loss of cultural and religious values relative to the utility of gains from adopting improved rice varieties.

In Table 3, we observed that the average number of times that farmers consulted the gods for adoption advice varied slightly between groups, such that Mole-Dagbani (3.392), Guan (3.001) and Gurma (3.797). While there is still some variation between groups less than 20% of the rice farmers do not consult gods before deciding to adopt improved rice, such that Mole-Dagbani (19%), Guan (12%) and Gurma (13%), demonstrating that the cultural practice is of significant importance to the majority of farmers. A similar effect is observed in the culture restriction for working days, with Mole-Dagbani (82%), Guan (86%) and Gurma (91%) observing the

Table 3
Test of difference.

Variable	Adoption n = 232		Non-Adoption n = 232		Pooled Sample n = 464		T-test	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Diff.	P-Value
Age	22.961	1.122	31.155	0.898	23.058	1.020	**−8.194****	0.040
Male	1.099	0.299	1.302	0.460	1.200	0.401	**−0.203*****	0.000
Household	2.685	1.159	2.638	0.877	2.662	1.027	0.047	0.619
Married	1.961	0.640	2.108	0.685	2.034	0.666	**−0.147****	0.018
Education	1.871	1.032	1.504	0.800	1.688	0.941	**0.366*****	0.000
Expenditure	21.897	30.304	23.884	32.372	22.890	31.289	−1.987	0.495
Primary Occ.	1.388	0.488	1.345	0.476	1.366	0.482	0.043	0.336
Farming Exp.	9.922	0.951	7.913	0.814	6.918	0.887	2.010	0.943
Farm system	1.159	0.367	1.056	0.230	1.108	0.310	**0.103*****	0.000
Extension	1.862	0.346	1.948	0.222	1.905	0.293	**−0.086*****	0.002
Credit Acc.	1.948	0.222	1.966	0.183	1.957	0.203	0.017	0.362

Legend: ***, ** and * represent 0.01, 0.05 and 0.1 significant levels respectively.

Table 4
Correlation by ethnicity and religion.

Ethnic Variables	Consultation of gods	Restriction by culture	Chief approval	Ancestors approval
Consultation of gods	1.0000			
Restriction by Culture	0.1334***	1.0000		
Chief approval	0.1508***	−0.5790***	1.0000	
Ancestors approval	0.2421***	−0.1419***	0.2566***	1.0000
Religious Variables	Restriction by Religion	Religious leader	Destiny	God blessing
Restriction by Religion	1.0000			
Religious leader	−0.3201***	1.0000		
Destiny	0.0659***	−0.0794	1.0000	
God blessing	0.0820***	−0.0189	0.5368***	1.0000

Spearman's Correlation. Legend: ***, ** and * represent 0.01, 0.05 and 0.1 significant levels respectively.

Table 5
Kruskal-Wallis test of ethnicity and religion.

	Rank Sum			χ^2	*p*-value	Pairwise Comparisons		
						1 vs 2	1 vs 3	2 vs 3
Ethnic Variables/ Groups	1. Mole-Dagbani (n = 192)	2. Gurma (n = 117)	3. Guan (n = 155)					
Consulting gods	41444.0	29723.0	36713.0	8.242	0.0002	**−28.2*****	**−21.0***	17.2
Restriction by culture	66076.0	17396.0	24408.0	248.76	0.0001	**19.5*****	**18.7*****	−8.8
Chief approval	57408.0	20156.5	28005.5	94.503	0.0001	**12.8*****	**11.2*****	−15.2
Ancestors approval	43006.0	26902.0	36122.0	0.956	0.0630	**−12.0***	**−18.7**	**−6.7***
Religious Variables/ Groups	**1. Christianity (n=129)**	**2. Islam (n=234)**	**3. Traditional (n=101)**					
Restriction by religion	24230.5	61687.0	21962.5	31.211	0.0001	**−75.8*****	**−29.6***	**46.2****
Religious leader	23044.5	57699.5	24826.0	19.801	0.0001	**−56.8*****	**−56.1*****	0.7
Destiny	33240.5	48161.0	26478.5	21.615	0.0001	**51.9*****	−4.5	**−56.3*****
God blessing	31458.5	49003.5	27418.0	19.324	0.0001	**34.4*****	**−27.6***	**−62.0*****

limitations (see Ref. [55]; p. 4). Given that a small number of farmers indicated that culture does not restrict farming days, further questioning revealed that farmers who indicated zero for both the consultation of gods and daily cultural restricts were inactive participants of cultural rules and those individuals with higher-than-normal education. Additionally, most of Gurma and Gua n ethnicity respondents agreed that ancestors' approval of agricultural technology played a critical role in adoption decision making. At the same time, most Mole-Dagbani were indifferent on the cultural practice.

Chiefs and sub-chiefs in Mole-Dagbani are very powerful persons, and subordinate will sometimes follow their instructions without question [60]; as a result, 60% strongly agreed that chief approval of modern technology carried significant weight. Alternatively, we observe much lower responses to the Ibrahim in the Gurma (9%) and Guan (8%) ethnic groups. The majority of the respondents accepted and strongly agreed that the cultural practices identified to contribute significantly to the current level of rice adoption in Northern Ghana. Respondents also revealed that religion impacts their practices and decision-making, as both the Mole-Dagbani and Gurma report that religion restricts farming for an average of four days. However, a significant number points out that, though sacred

days are important in their life, it does not prevent them from undertaking their farming activities. While most Christians and Traditionalists disagreed that the religious leader approval of agricultural technology does influence their decision, 33% of Muslim farmers were uncertain about the effects of an Imam approval of agricultural technology on his followers. Over 80% of farmers in all the religious faiths believed that destiny and the showering of favourable weather condition by God are critical factors that affect their adoption decision, and responses for destiny and the blessing of God through favourable climatic conditions are similar.

We assume there will be some overlap between ethnic and religious groups even if they derive from different populations; we use the Kruskal-Wallis (KW) test and Spearman's rank tests. The KW test is non-parametric one-way ANOVA to verify the similarity or difference among the group show that there is a significant difference in the number of times farmers consult gods, days culture restricts farming, chief approval of agricultural technology and acceptance by ancestors among the groups. Only ancestors' approval is significant at a 90% confidence level; the rest are statistically significant at one per cent ($p < 0.01$). The estimates of the groups after the KW test show that Mole-Dagbani and Gurma are a significant difference at 1% for consultation of gods, days restricted by culture for farming and approval of chief. Mole-Dagbani is significantly different from Guan in days restricted by culture and the chief approval at one per cent and ten per cent for consultation of gods. In all the pairs, Gurma is insignificantly different from Guan except the case of ancestors' approval ($p < 0.1$).

The test of religious group differences in Table 4 shows that all are statistically significant at one per cent for days restricted by religion, the approval of a religious leader, the belief in destiny and the blessing of God respectively. The days restricted by religion are significantly different between Christianity and Islam ($p < 0.01$), Christianity and Traditional ($p < 0.10$), and Islam and Traditional ($p < 0.05$). The belief in Destiny is significantly different between Christianity and Islam ($p < 0.01$) and Islam and Traditional ($p < 0.01$), but not between Christianity and Traditional. The impact of religious leaders is significant differences between Christianity and Islam ($p < 0.01$) and between Christianity and Traditional ($p < 0.01$), but not between Islam and Traditional.

7. Regression analysis

Table 6 reports the probit regression model results for the determinants of adoption of new rice variants based upon cultural (ethnic) factors and Table 7 reports the results on the religious factors. The Cultural determinants of adoption in Table 6 follow some rationally predictable outcomes as *household* size, *education* and farming *experience* are all positively significant. One would expect that as households get larger farmers should be more willing to adopt the yield increasing rice varieties, more education and experience would also imply that farmers know the best avenues to maximise crop yields. Additionally, as daily *expenditure* decreases (i.e. the farmers become poorer), they are less likely to adopt the technology. However, we observe that the Mole-Dagbani has a significant and robustly negative effect on adoption while being a member of the Gurma or the Guan has an insignificant impact. We also observe that *cultural restrictions* on the days allowed to access the farm and the need to *consult the ancestors* are robust and negatively affect adoption. Finally, not having access to the *extension service* is likely to significantly reduce the farmers' willingness to adopt improved rice varieties.

We observe in Table 7 some distinct religious differences about the adoption of new variants. Firstly, *age* is robustly significant across all models and has become strongly negative. This shows that *religion* is not only much stronger determinant than *culture* for farmers on adoption, but for older farmers, it is a significantly strong deterrent which implies that there may be a generational effect occurring. This generational effect is further supported by the robust results of *education*, as higher education levels overcome cultural and religious barriers to successful adoption. In line with the support of the leaders for GM crops, *Christian* farmers are significantly more likely to adopt *Islamic* farmers are not. We observe similar results in both Culture and Religious models as *restrictions* have a significantly negative effect on adoption; we also see a significantly negative effect on *Destiny* and Seeking *God's Blessing*.

What is strikingly different in the religious models is that being a *Traditional* religious follower has no significant effect on adoption, this is likely to signify that cultural norms are more important than religious for this group of farmers. While somewhat counter-intuitive, farmers who have a large number of *household* members (i.e. mouths to feed) are less likely to adopt the greater yield improved rice seed, however, if we assume that older farmers are likely to have a greater number of children and potentially elderly parents living in the home, then, older farmers are less likely to adopt. Finally, since most Mole-Dagbani are Muslims,[8] we get a double impact of culture and religion, resulting in the significant negative likelihood of adoption.

8. Discussion

Our research findings show an amazing result regarding prospect theory. Based on the regression analysis, rice farmers attached greater importance to cultural and religious factors vis-a-vis the benefit of adopting hybrid rice seed for production. We can see from both the religious and cultural results that, all the eight societal values are critical norms that rice farmers consider before taking adoption decision except, religious leaders' approval. For farmers to personally select whether to growth improved rice to get more yield or based his decision on the established community law, the later will be given much attention. We observed that, consultation of farmers dead fathers, given priority to the decision of chiefs, ad her to days people are not supposed to attend to farming activities and to wait for the approval of tribal gods are attractive package to rice farmers relative to the fight of poverty and hunger through the adoption of high yield and disease resistance breeds of rice.

[8] Ghana Statistical Service (2010) reports the 58% of Mole-Dagbani are Muslims and 25% are Christians.

Table 6
Adoption determinants (culture).

Probit	(1)		(2)		(3)		(4)		(5)	
	β/Z-Value	**M.E**	**β/Z-Value**	**M.E**	**β/Z-Value**	**M.E**	**β/Z-Value**	**M.E**	**β/Z-Value**	**M.E**
Age	0.217*	0.086	0.178	0.071	0.179	0.071	0.280**	0.11	0.319**	0.126
	(1.73)		(1.36)		(1.38)		(1.97)		(2.18)	
Sex	−0.080	−0.032	−0.038	−0.037	−0.095	−0.038	−0.172	−0.068	−0.121	−0.048
	(-0.36)		(-0.41)		(-0.42)		(-0.71)		(-0.48)	
Household Size	0.197*	0.078	0.234*	0.093	0.234*	0.093	0.221	0.087	0.342**	0.135
	(1.73)		(1.59)		(1.94)		(1.69)		(2.39)	
Marital Status	−0.195	−0.077	−0.227	−0.090	−0.228	−0.090	−0.209	−0.082	−0.172	−0.068
	(-1.01)		(-1.16)		(-1.16)		(-1.06)		(-0.86)	
Education Status	0.226	0.090	0.300*	0.119	0.300*	0.119	0.511***	0.201	0.509**	0.201
	(1.51)		(1.87)		(1.87)		(2.83)		(2.68)	
Daily Expenditure	−0.006**	−0.002	−0.007**	−0.003	−0.008**	−0.003	−0.011***	−0.005	−0.011***	−0.004
	(-2.00)		(-2.36)		(-2.36)		(-3.02)		(-2.77)	
Primary Occupation	0.306	0.122	0.278	0.111	0.279	0.110	0.350	0.138	0.331	0.130
	(1.34)		(1.20)		(1.20)		(1.40)		(1.29)	
Farming Experience	0.232*	0.092	0.332**	0.132	0.333**	0.132	0.548***	0.216	0.514***	0.203
	(1.89)		(2.51)		(2.50)		(3.49)		(3.11)	
Farming System	−0.143	−0.057	−0.251	−0.102	−0.258	−0.103	−0.452	−0.178	−0.372	−0.147
	(-0.28)		(-0.51)		(-0.51)		(-0.89)		(-0.73)	
Extension Service	−1.274***	−0.506	−1.251***	−0.497	−1.252***	−0.497	−1.110***	−0.437	−0.927**	−0.366
	(-3.02)		(-2.97)		(-2.93)		(-2.59)		(-2.08)	
Credit Access	1.592*	0.449	1.006	0.400	1.010	0.401	1.106	0.436	0.903	0.356
	(1.02)		(1.59)		(0.64)		(1.68)		(1.30)	
Mole-Dagbani	−0.211***	−0.086	−0.264**	−0.079	−0.370*	−0.064	−0.401***	−0.051	−0.505**	−0.071
	(-1.35)		(-1.69)		(-1.32)		(-2.86)		(-1.43)	
Gurma	−0.106	−0.007	−0.105	−0.005	−0.111*	−0.010	−0.151	−0.009	−0.091	−0.012
	(-2.00)		(-2.43)		(-2.76)		(-3.75)		(-2.24)	
Guan	0.236	0.102	0.338	0.110	0.209	0.116	0.276	0.108	0.331	0.060
	(1.54)		(1.62)		(1.20)		(1.49)		(1.39)	
gods Consultation			−0.332***	−0.132	−0.333**	−0.132	−0.440*	−0.173	−0.470***	−0.186
			(-2.84)		(-2.84)		(-3.20)		(-3.27)	
Culture Restriction					−1.723***	−0.652	−0.827***	−0.326	−0.880*	−0.347
					(-3.58)		(-3.21)		(-3.09)	
Chief Approval							0.292***	0.111	0.219**	0.086
							(2.62)		(2.64)	
Ancestors Approval									0.087***	0.108
									(2.62)	
Observation	464		464		464		464		464	
Prob.>chi^2	0.000		0.000		0.000		0.000		0.000	
Pseudo R^2	0.2514		0.2749		0.4409		0.4706		0.4720	

We observed rice farmers as technological risk-averse but cultural and religious risk-lovers. The situation of Northern Ghana rice farmers suggests that farmers know the benefits of adopting improved rice varieties. However, some could not adopt because the chief did not make a formal declaration to that effect. Some farmers distance themselves from the non-traditional varieties because of dual rejection by the ancestors and their gods, or one of the traditional beliefs' outcome indicates negative. Constant attending to farming issues without restriction to some days according to modern farming system raised doubt about the compatibility of modern technology with the traditional farming practice, which limits farming to some days. We observed self-interest behaviour of farmers to keep the cultural values to the highest esteem and ignore the benefits of hybrid rice when the two are presented for choice. The intensity of weight placed on cultural values varied across ethnic groups with Guan, Gurma and Mole-Dagbani in ascending order are significant, cultural values in general, are critical element regarding decision to adopt agricultural technology.

Religious faith among the farmers was not different compared to farmers' adoption. Saturdays and Sundays are considered *Spiritual days* to different Christian faiths, Friday as a *Holiday* to the Muslims faith and Mondays, Thursday and Fridays are *Taboo days* to the Traditionalist in Northern Ghana. Farmers valued the selected *restricted* days to the extent that even if they would harvest "*God and Diamond*" in those days, they will not go to the farm. The reason is either punishment will impose on them, or God will not bless the commodity they will get. Farmers from the various faiths believed in God as the provider of food and water and not technology. We hear comment such as "*whoever God creates to be rich will be rich, and the poor will be poor*". No doubt *Destiny* and the *Blessing of God* are strongly connected to adoption negatively. The strong believed of farmers to *Religious Days, Destiny* and the *Blessing of God* implies that regardless of the benefit of improved rice agricultural officer preach to them, farmers make decisions based on religious rules.

We observed that integrating cultural and religious beliefs is important as both influences the behaviour of farmers. Muslim majority tribe such as Mole-Dagbani farmers place greater weight on Islamic values at the expense of growing improved rice varieties. As such, the result shows that farmers in Mole-Dagbani tribe resistant to adoption while Christian dominated tribe like Guan indicate a positive relationship to adoption. This clearly explains Kahneman's Prospect Theory in which farmers overweigh the loss of cultural and religious values relative to the merits of adopting improved rice varieties. From our analysis the minority farmers who adopted

Table 7
Adoption determinants (religion).

Probit	(1)		(2)		(3)		(4)		(5)	
	β/Z-Value	M.E	β/Z-Value	M.E	β/Z-Value	M.E	β/Z-Value	M.E	β/Z-Value	M.E
Age	−0.404**	−0.601	−0.416**	−0.166	−0.431**	−0.172	−0.496**	−0.198	−0.499*	−0.199
	(-2-21)		(-2.22)		(-2.08)		(-2.10)		(-1.90)	
Sex	0.782***	0.304	0.770***	0.299	0.773**	0.301	0.866***	0.335	1.045***	0.398
	(2.64)		(2.58)		(2.59)		(2.74)		(3.06)	
Household Size	−0.438**	−0.174	−0.466**	−0.185	−0.456**	−0.182	−0.358	−0.143	−0.501*	−0.199
	(-2.14)		(-2.21)		(-2.09)		(-1.54)		(-1.91)	
Marital Status	0.278	0.111	0.265	0.105	0.268	0.107	0.151	0.060	0.149	0.059
	(1.11)		(1.03)		(1.04)		(0.55)		(0.52)	
Education Status	0.889***	0.354	0.827***	0.329	0.823***	0.328	0.928***	0.370	1.169***	0.466
	(3.61)		(3.30)		(3.26)		(3.40)		(3.56)	
Daily Expenditure	−0.008	−0.003	−0.007	−0.003	−0.007	−0.003	−0.006	−0.002	−0.001	−0.001
	(-1.10)		(-0.99)		(-0.81)		(-0.70)		(-0.16)	
Primary Occupation	−1.122***	−0.536	−1.377***	−0.548	−1.381***	−0.549	−1.557***	−0.621	−1.894***	−0.755
	(-2.66)		(-2.27)		(-2.72)		(-2.84)		(-2.88)	
Farming Experience	0.130	0.052	0.123	0.049	0.131	0.052	0.044	0.018	0.112	0.045
	(0.76)		(0.71)		(0.73)		(0.238)		(0.53)	
Farming System	−1.122***	−0.416	−1.146***	−0.424	−1.135***	−0.420	−1.161***	−0.433	−1.172***	−0.438
	(-3.51)		(-3.53)		(-3.43)		(-3.31)		(-3.16)	
Extension Service	−0.181	−0.072	−0.138	−0.055	−0.148	−0.059	−0.234	−0.093	−0.366	−0.145
	(-0.61)		(-0.45)		(-0.48)		(-0.73)		(-1.08)	
Credit Access	−0.367	−0.145	−0.380	−0.151	−0.378	−0.149	−0.391	−0.155	−0.402	−0.159
	(-1.24)		(-1.27)		(-1.26)		(-1.27)		(-1.25)	
Christianity	0.043**	0.011	0.040***	0.016	0.0374**	0.041	0.075***	0.035	0.045***	0.071
	(2.74)		(1.58)		(2.59)		(1.79)		(2.06)	
Islam	−0.268**	−0.136	−0.276**	−0.115	−0.166**	−0.102	−0.308	−0.143	−0.401	−0.223
	(-0.14)		(-1.21)		(-2.23)		(-1.54)		(-1.33)	
Traditional	−0.278	−0.111	−0.265	−0.105	−0.268	−0.107	−0.151	−0.060	−0.149	−0.059
	(-1.11)		(-1.03)		(-1.04)		(-0.55)		(-0.52)	
Religion Restriction			−0.156***	−0.062	−0.136**	−0.054	−0.182*	−0.073	−0.401*	−0.159
			(-1.09)		(-0.74)		(-0.90)		(-1.75)	
Religious Leader					0.028	0.011	0.597*	0.238	0.769	0.307
					(0.17)		(1.85)		(2.04)	
Destiny							−0.174**	−0.349	−0.166**	−0.361
							(-2.02)		(-1.88)	
God blessing									−0.524**	−0.209
									(-2.45)	
Observation	464		464		464		464		464	
Prob.>chi^2	0.000		0.000		0.000		0.000		0.000	
Pseudo R^2	0.1611		0.1942		0.1947		0.2511		0.2782	

hybrid rice do not abandon the cultural and religious rules. Any farming education that follows within the sacred days will get a very low attendance, and farmers will not engage in any farming activities even for a week because of a durbar organised by a chief.

We can clearly state that, if farmers do not over-value the coins of neglecting cultural and religious regulations, adoption of improved rice will have been high. Farmers testified that the government informed them the benefit of hybrid rice, make the seed accessible to them and even subsidised the seed. But the seed adoption's consequences are observed by farmers to be greater than the benefits. We observed that farmers see adopting the technology as an opportunity cost of losing cultural and religious values and they prefer to have the societal norms than to eradicate poverty and hunger and have a changing society.

9. Conclusions

Despite extensive previous research on agricultural technology adoption, especially on improved rice seeds, rice green revolution remains comparatively low in Northern Ghana. This paper aimed to explore the impact of cultural and religious factors on the adoption of improved rice varieties (technology) with farmers in Northern Ghana. The prior research focused on socio-demographic and traditional economic approaches, resulting in very patchy explanatory power and no consistent outcomes. This research took a behavioural economics perspective and included factors such as social norms derived from culture and religion. In employing the non-tradition approach, the research considered prospect theory because of the value attached to social norms by farmers versus the benefits of modern rice technology.

Based on the findings of this study, micro-level policies are identified to promote the adoption of agricultural technology, especially, improved rice kinds. Technology diffusion activities should integrate cultural and religious norms through chiefs and religious leaders. Chiefs should be actively involved in the communication and practical used of any modern rice seed. When a chief accepts technology, as an opinion leader of culture in the community, it neutralises the other cultural factors. Policies can not directly change cultural and religious rules; however, changing the maker's attitude toward the norms implies changing society.

Furthermore, Islamic communities need assiduity. Muslims resistance to adopting hybrid rice is why Northern Ghana's low usage rate. Northern Ghana has the highest Muslims population with high illiteracy. Mole-Dagbani is the dominant ethnic group with high Muslims. The region adoption rate is boostable through Mole-Dagbani kings-men. Sensitising the natives about modern agriculture through formal education will transform their beliefs about crop production. Adapting Norman's approach of persuading political leaders in Asia and some part of Africa to accept his green revolution, diffusion of agricultural technology is achievable through changing the leaders of cultural and religious groups. According to D. M. [61]; the decision of followers significantly induced by their leaders irrespective of whether the leader is elected or selected.

This research has limitations and gaps that could be looking at in future. The main concern is the measurement of values attached to the cultural and religious norms. Future research could draft a scale for respondents to state the value attached to social norms. Comparing the loss values of social norms to the quantity of rice is important. The lack of measurement scale for social norms led to a qualitative comparison of the utility of rice benefits and disutility of loss of social norms. Both quantitative and qualitative relativity have their merits and demerit. The critical advantage of the qualitative approach is the diversion of the traditional behavioural research method. Given the importance of adoption in Ghana, the researchers hope that future studies will dwell on the quantitative components of social norms to pave the way for parametric models.

9.1. Limitation

Among the gaps identified during the literature review concerns the use of longitudinal data to study technology adoption; this approach is especially critical in northern Ghana, where there is a decades-long history of farming rice. Further, the cultures and religions this paper brought into relation with adoption have existed for a long time. Studying the changes that have occurred in the cultures, affecting their past and current relationship with agriculture, could help contextualize and explain the focal variables of the research. However, we depended on short-term survey data, spanning four months, to conduct the present analysis.

The findings of this thesis are limited to northern Ghana and areas in other West African countries where similar cultures are found, such as the Mole and the Guan in Nigeria. Furthermore, the area selected for this study is the region with the highest poverty level in Ghana; it also has the most heterogeneous cultural and religious practices among the country's various regions. It is important to expand on this study by analysing the effects of social norms on adoption decisions, technical efficiency, and farmer welfare across the many groups in the whole of Ghana. For instance, researchers could compare the adoption of improved rice varieties, technical efficiency, and welfare in southern Ghana versus northern Ghana, or in a one-rainy season zone versus a two-rainy season zone, or among subsistence farmers versus commercial farmers. Such comparisons could inform policy across different groups in Ghana.

Declarations

Author contribution statement

Mohammed Tanko Conceived and designed the experiment and Perform the experiment. Munira Alhassan Muhammed Analysed and interpretated the data. Salifu Ismaila Contributed reagents, material, analysis, or data and Wrote the paper.

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Data availability statement

Data associated with this study has been deposited at https://data.mendeley.com/datasets/vt6sny327k/1.

Declaration of interest's statement

The authors do not have any competing interest.

Additional information

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.heliyon.2022.e12783.

Appendix

We conducted robustness tests on the multiple ethnic regression by considering a religious variable, which was coded as one for a specific religion and zeroes otherwise. The results of the robustness test reported in Table 8 show that farmers from various ethnic

group belong to at least one of the religious denominations, and the faith in that religion could influence the cultural rules and regulations. The analysis shows that all the cultural factors (consultation of gods, cultural restriction, chief approval and ancestors' approval) significantly affect the adoption decision of rice farmers. Cultural factors such as consultation of gods and the days restricted by culture inversely affect adoption decision. At the same time, the approval of the chief and ancestors positively affects the adoption decision. This supports [62] assertion that culture is a critical factor in the diffusion of technology and is evident in Northern Ghana rice farmers.

Table 8
Robustness check on cultural variables.

Probit	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age	0.364*	0.288	0.288	0.469**	0.542**	1.204***	1.038***	1.144***	1.174***
	(1.74)	(1.35)	(1.30)	(1.99)	(2.18)	(3.43)	(2.94)	(2.87)	(2.85)
	0.090	**0.071**	**0.072**	**0.115**	**0.133**	**0.284**	**0.244**	**0.266**	**0.274**
Male	−0.145	−0.151	−0.151	−0.301	−0.201	−0.577	−0.625	−0.610	−0.553
	(-0.39)	(-0.40)	(-0.39)	(-0.73)	(-0.47)	(-1.11)	(-1.15)	(-1.12)	(-0.99)
	−0.036	**−0.037**	**−0.038**	**−0.074**	**−0.049**	**−0.138**	**−0.149**	**−0.144**	**−0.131**
Household Size	0.326*	0.401**	0.401**	0.395*	0.561**	0.525*	0.580*	0.507	0.711*
	(1.74)	(2.01)	(2.00)	(1.80)	(2.37)	(1.66)	(1.72)	(1.43)	(1.89)
	0.081	**0.100**	**0.100**	**0.097**	**0.138**	**0.124**	**0.137**	**0.118**	**0.166**
Married	−0.287	−0.341	−0.341	−0.314	−0.262	−0.831*	−0.696	−0.725	−0.645
	(-0.92)	(-1.07)	(-1.07)	(-0.96)	(-0.80)	(-1.76)	(-1.45)	(-1.48)	(-1.30)
	−0.071	**−0.085**	**−0.085**	**−0.077**	**−0.064**	**−0.196**	**−0.164**	**−0.168**	**−0.150**
Education	0.390	0.495*	0.495*	0.891***	0.850***	1.810***	1.97***	1.987***	2.063***
	(1.49)	(1.77)	(1.77)	(2.81)	(2.64)	(3.58)	(3.67)	(3.69)	(3.79)
	0.097	**0.123**	**0.123**	**0.218**	**0.209**	**0.428**	**0.465**	**0.461**	**0.482**
Expenditures	−0.010*	−0.013**	−0.012**	−0.019***	−0.019***	−0.040***	−0.041***	−0.041***	−0.040***
	(-1.93)	(-2.31)	(-2.31)	(-2.95)	(-2.69)	(-3.17)	(-3.21)	(-3.25)	(-3.29)
	−0.002	**−0.003**	**−0.003**	**−0.005**	**−0.005**	**−0.009**	**−0.010**	**−0.010**	**−0.009**
Occupation	0.482	0.433	0.432	0.576	0.573	0.130	0.198	0.135	0.1160
	(1.28)	(1.14)	(1.14)	(1.40)	(1.35)	(0.023)	(0.34)	(0.23)	(0.26)
	0.120	**0.107**	**0.107**	**0.141**	**0.141**	**0.031**	**0.047**	**0.031**	**0.037**
Experience	0.377*	0.565**	0.565**	0.957***	0.859***	1.354***	1.314***	1.327***	1.123
	(1.86)	(2.47)	(2.47)	(3.49)	(3.06)	(3.38)	(3.36)	(3.38)	(2.90)
	0.093	**0.014**	**0.140**	**0.234**	**0.211**	**0.320**	**0.309**	**0.308**	**0.262**
Farm System	−0.275	−0.461	−1.462	−0.804	−0.653	−0.044	−0.227	−0.260	−0.001
	(-0.34)	(-0.57)	(-0.57)	(-0.97)	(-0.77)	(-0.05)	(-0.23)	(-0.27)	(-0.01)
	−0.068	**−0.115**	**−0.115**	**−0.197**	**−0.160**	**−0.010**	**−0.053**	**−0.060**	**−0.000**
Extension	−2.062***	−2.040***	−2.040***	−1.832**	−1.54**	−1.188	−1.070	−1.054	−1.472
	(-2.90)	(-2.77)	(-2.77)	(-2.48)	(-2.00)	(-1.30)	(-1.15)	(-1.14)	(-1.55)
	−0.512	**−0.506**	**−0.507**	**−0.448**	**−0.379**	**−0.281**	**−0.252**	**−0.245**	**−0.344**
Credit Access	1.867*	1.559	1.560	1.827	1.536	0.772	0.316	0.272	1.118
	(1.78)	(1.42)	(1.42)	(1.60)	(1.30)	(0.53)	(0.21)	(0.18)	(0.71)
	0.463	**0.387**	**0.388**	**0.447**	**1.792**	**0.182**	**0.074**	**0.063**	**0.261**
Mole-Dagbani	−0.205**	−0.207*	−0.212	−0.462*	−0.472*	−0.484*	−0.492*	−0.553**	−0.569*
	(-0.89)	(-0.88)	(-0.91)	(-1.79)	(-1.80)	(-1.82)	(-1.83)	(-1.98)	(-1.94)
	−0.048	**−0.048**	**−0.050**	**−0.106**	**−0.109**	**−0.112**	**−0.114**	**−0.127**	**−0.126**
Gurma	−0.404	−0.467	−0.503	−0.252	−0.253	−0.264	−0.269	−0.228	−0.335
	(-1.18)	(-1.34)	(-1.44)	(-0.68)	(-0.68)	(-0.71)	(-0.72)	(-0.61)	(-0.88)
	−0.149	**−0.171**	**−0.183**	**−0.095**	**−0.095**	**−0.099**	**−0.101**	**−0.086**	**−0.122**
Guan	0.167	0.172	0.159	0.282	0.283	0.276	0.301	0.247	0.328
	(1.09)	(1.07)	(1.00)	(1.67)	(1.68)	(1.61)	(1.65)	(1.26)	(1.45)
	0.064	**0.066**	**0.061**	**0.108**	**0.109**	**0.106**	**0.116**	**0.094**	**0.122**
Consult gods		−0.576***	−0.576***	−0.764***	−0.780***	−1.148***	−1.233***	−0.231***	−1.049***
		(-2.82)	(-2.82)	(-3.14)	(-3.18)	(-3.29)	(-3.37)	(-3.35)	(-3.19)
		−0.143	**−0.143**	**−0.187**	**−0.192**	**−0.271**	**−0.290**	**−0.285**	**−0.267**
			−0.000	−0.020	0.028	−0.035	−0.035	−0.038	−0.045
Consult gods (1–2)			(-0.01)	(-0.45)	(-0.63)	(-0.76)	(-0.75)	(-0.81)	(-0.94)
			−0.000	**−0.005**	**−0.007**	**−0.008**	**−0.008**	**−0.009**	**−0.011**
Consult gods (2–3)				−1.404**	−1.480**	−2.72*	−2.734	−2.888**	−2.884**
				(-3.20)	(-3.15)	(-3.48)	(-3.50)	(-3.44)	(-3.55)
				−0.343	**−0.364**	**−0.644**	**−0.644**	**−0.670**	**−0.673**
Cultural restriction					−0.346**	−0.352**	−0.339*	−0.360**	−0.521**
					(-2.46)	(-2.08)	(-1.20)	(-2.04)	(-2.61)
					−0.085	**−0.083**	**−0.080**	**−0.084**	**−0.121**
Cultural restrict (1–2)						−1.043***	−0.995*	−1.009**	−1.064**
						(-5.06)	(-4.62)	(-4.68)	(-4.82)
						−0.246	**−0.234**	**−0.234**	**−0.248**

(*continued on next page*)

Table 8 (*continued*)

Probit	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Cultural restrict.							−0.503**	−0.202	−0.50*
(2–3)							(-2.69)	(-2.67)	(-2.64)
							−0.116	**−0.117**	**−0.118**
Chief Approve								0.135*	0.151
								(0.14)	(0.67)
								0.191	**0.185**
Ancestors Approve									0.390***
									(2.08)
									0.148
Christianity	Yes	Yes	Yes	Yes	Yes**	Yes*	Yes*	Yes	Yes
Islam	Yes	Yes	Yes	Yes**	Yes	Yes	Yes	Yes	Yes
Traditional	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Prob.>chi^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R^2	0.1581	0.1938	0.1948	0.2514	0.2749	0.4409	0.4706	0.4720	0.4895

Table 9 reports the robustness test results for religion regression analysis. After including ethnic dummies and differences in days religion restrict farming between the groups in the specified models indicate insignificant change within the non-focus variables. Aside from destiny and blessing from God, none of the focus and the non-focus variables hardly change. Some of the variables significant levels fluctuate with the inclusion of another variable a prior sign remains the same. As such, it is justifiable to believe that religious values are at least weakly impacting adoption decisions compared to cultural practice and that the impact of social norms explained through the individual variables.

Table 9
Robustness check on religious variables.

Probit	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Age	−0.679**	−0.687**	−0.719**	−0.816**	−0.872**	−0.750	−0.754	−0.756*
	(-2.17)	(-2.15)	(-2.05)	(-2.06)	(-1.96)	(-1.64)	(-1.62)	(-1.65)
	−0.168	**−0.171**	**−0.179**	**−0.204**	**−0.218**	**−0.187**	**−0.188**	**−0.189**
Sex	1.401**	1.377**	1.386**	1.553***	1.834***	1.724***	1.714***	1.705**
	(2.65)	(2.60)	(2.61)	(2.76)	(3.00)	(2.75)	(2.57)	(2.55)
	0.335	**0.329**	**0.332**	**0.369**	**0.429**	**0.405**	**0.403**	**0.401**
Household Size	−0.864**	−0.873**	−0.852**	−0.693*	−0.919**	−1.289**	−1.283**	−1.283**
	(-2.27)	(-2.29)	(-2.17)	(-1.66)	(-1.98)	(-2.36)	(-2.28)	(-2.28)
	−0.214	**−0.217**	**−0.212**	**−0.173**	**−0.229**	**−0.322**	**−0.320**	**−0.320**
Marital Status	0.642	0.586	0.595	0.395	0.286	0.858	0.849	0.888
	(1.38)	(1.25)	(1.26)	(0.79)	(0.57)	(1.41)	(1.33)	(1.34)
	0.159	**0.146**	**0.148**	**0.099**	**0.071**	**0.214**	**0.212**	**0.222**
Education Status	1.493***	1.407***	1.396***	1.559***	2.043***	2.135***	2.136***	2.161***
	(3.51)	(3.25)	(3.21)	(3.31)	(3.38)	(3.13)	(3.12)	(3.09)
	0.371	**0.349**	**0.347**	**0.389**	**0.511**	**0.532**	**0.533**	**0.539**
Daily Expenditure	−0.014	−0.013	−0.012	−0.011	−0.004	−0.023	−0.024	−0.025
	(-1.66)	(-1.06)	(-0.85)	(-0.74)	(-0.24)	(-1.08)	(-1.05)	(-1.06)
	−0.004	**−0.003**	**−0.003**	**−0.003**	**−0.001**	**−0.006**	**−0.006**	**−0.006**
Primary Occupation	−2.293***	−2.299***	−2.301***	−2.583***	−3.251***	−3.234**	−3.241***	−3.235***
	(-2.66)	(-2.67)	(-2.67)	(-2.79)	(-2.81)	(-2.42)	(-2.40)	(-2.39)
	−0.569	**−0.572**	**−0.572**	**−0.645**	**−0.813**	**−0.807**	**−0.809**	**−0.807**
Farming Experience	0.154	0.161	0.179	0.022	0.219	0.094	0.091	0.079
	(0.50)	(0.51)	(0.56)	(0.06)	(0.55)	(0.20)	(0.19)	(0.17)
	0.038	**0.040**	**0.045**	**0.005**	**0.055**	**0.024**	**0.023**	**0.019**
Farming System	−2.040***	−2.027***	−2.002***	−2.053***	−2.066***	−2.336***	−2.343***	−2.323***
	(-3.45)	(-3.42)	(-3.33)	(-3.27)	(-3.02)	(-3.04)	(-2.99)	(-2.94)
	−0.451	**−0.451**	**−0.446**	**−0.462**	**−0.467**	**−0.519**	**−0.521**	**−0.518**
Extension Service	−0.358	−0.276	−0.298	−0.443	−0.729	−0.532	−0.535	−0.538
	(-0.67)	(-0.51)	(-0.54)	(-0.78)	(-1.18)	(-0.84)	(-0.84)	(-0.85)
	−0.089	**−0.068**	**−0.074**	**−0.110**	**−0.180**	**−0.132**	**−0.133**	**−0.133**
Credit Access	−0.665	−0.681	−0.679	−0.669	−0.669	−0.918	−0.919	−0.904
	(-1.29)	(-1.31)	(-1.31)	(-1.26)	(-1.19)	(-1.51)	(-1.51)	(-1.48)
	−0.164	**−0.168**	**−0.168**	**−0.166**	**−0.166**	**−0.224**	**−0.224**	**−0.221**
Christianity	0.056***	0.060***	0.061**	0.057***	0.058***	0.058***	0.059***	0.059*
	(4.16)	(4.13)	(4.24)	(3.87)	(3.86)	(3.77)	(3.76)	(3.50)
	0.021	**0.023**	**0.023**	**0.022**	**0.022**	**0.022**	**0.023**	**0.023**
Islam	−1.635***	−1.702***	−1.605***	−1.566**	−0.561***	−1.570***	−1.595**	−1.573*
	(-3.24)	(-3.30)	(-3.07)	(-2.64)	(-2.64)	(-2.61)	(-2.60)	(-2.60)
	−0.628	**−0.652**	**−0.614**	**−0.601**	**−0.599**	**−0.603***	**−0.613**	**−0.602**

(*continued on next page*)

Table 9 (*continued*)

Probit	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Traditional	−0.116	−0.118	−0.125	−0.267*	−0.271*	−0.281	−0.286*	−0.313**
	(-0.89)	(-0.89)	(-0.94)	(-1.82)	(-1.83)	(-1.87)	(-1.89)	(-2.01)
	−0.044	**−0.045**	**−0.048**	**−0.102**	**−0.104**	**−0.108**	**−0.110**	**−0.120**
Religion restriction		−0.212*	−0.168*	−0.265	−0.666*	−0.915*	−0.924*	−0.929*
		(-0.83)	(-0.52)	(-0.73)	(-1.64)	(-1.88)	(-1.77)	(-1.76)
		−0.053	**−0.042**	**−0.066**	**−0.166**	**−0.228**	**−0.231**	**−0.232**
Religion restricts. (1–2)			−0.061**	−0.984*	−1.338**	−1.265**	−1.457**	−1.427**
			(-0.22)	(-1.78)	(-2.03)	(-2.21)	(-2.12)	(-2.04)
			−0.015	**−0.246**	**−0.335**	**−0.366**	**−0.364**	**−0.356**
Religion restricts. (2–3)				1.447	1.577	1.106	1.093*	1.123*
				(1.93)	(1.86)	(1.20)	(1.13)	(1.14)
				0.362	**0.394**	**0.276**	**0.273**	**0.280**
Religion restricts. (3–1)					0.943	0.665*	0.668	0.679*
					(2.39)	(1.54)	(1.54)	(1.55)
					0.236	**0.166**	**0.167**	**0.169**
Religious Leader						1.372	1.368	1.356
						(2.16)	(2.15)	(2.12)
						0.342	**0.341**	**0.338**
Destiny							−0.197***	−0.012
							(-0.05)	(-0.03)
							−0.405	**−0.303**
God blessing								−0.131***
								(-0.22)
								- 0.333
Mole-Dagbani	Yes	Yes	Yes	Yes	Yes*	Yes**	Yes**	Yes**
Gurma	Yes	Yes	Yes	Yes	Yes*	Yes*	Yes*	Yes*
Guan	Yes	Yes	Yes	Yes	Yes*	Yes*	Yes*	Yes*
Prob.>chi^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Pseudo R^2	0.356	0.361	0.370	0.387	0.426	0.460	0.464	0.471

The cultural and religious practices used as social-norms variables indicated in Table 10 are drawn from research on social and cultural values affecting the development of agriculture and from the work of extension agents in northern Ghana (See Food and Agricultural Organisation, 2018a). The research collected the farmers' opinions about technology adoption, and their statements indicate their unwillingness to adopt agricultural technology due to the values attached to cultural and religious norms. Statements such as "How can it be better than our way?" and "We know what is best for us" motivated this thesis, which studies social norms as critical factors for decision-making processes about technology adoption (See Food and Agricultural Organisation, 2018b). The statements are qualitative evidence of farmers' resistance to adopting technology, which needs to be studied empirically.

Table 10
Description of variables.

Variable	Description	Unit of Measurement	A Priori Expectation
Non-Focal Variables			
Age	Age of the farmer	Years	+/−
Gender	Gender of the farmer	Dummy: 1 = male and 0 = female	+/−
Household size	Household size of the farmer	Number of household members	+
Marital status	Marital status of the farmer	Dummy: married = 1, otherwise = 0	+
Education	The farmer's level of education	Years	+/−
Income	Monthly income of the farmer	GH₵	+
Experience	Farmer's level of experience with rice cultivation	Years	+
Off-farm activities	The farmer participate in off-farm activities	Dummy: yes = 1, otherwise = 0	+/−
Extension	The farmer has access to extension services	Dummy: yes = 1, otherwise = 0	+/−
Credit access	The farmer has access to credit	Dummy: yes = 1, otherwise = 0	+/−
Farming system	The system of farming practice	Dummy:Only rice = 1, otherwise = 0	+/−
Risk	Farmer's risk attitude	Risk level of farmers	+/−
Focal Variables			
Cultural Factors			
Number of times gods need to be consulted	Number of visits to the gods	Times in a season	–
Number of days tradition restricts farming	Days not allowed to go to the farm	Days in a week	–
Permission from chief to adopt	Subjects need chief's approval before adoption	Categorical: 1–5	+
Ancestors' approval to adopt	Subjects need ancestors' approval before adoption	Categorical: 1–5	+
Religious Factors			
Number of days religion restricts farming	Days not allowed to go to the farm	Days in a week	–
Permission from a religious leader	Religious leader's approval	Categorical: 1–5	+
Destiny is fixed	Belief in God	Categorical: 1–5	–
God's blessing	Belief in God	Categorical: 1–5	–

References

[1] A. Smith, An Inquiry into the Nature and Causes of the Wealth of Nations, Charles Knight, London, 1779.
[2] T.R. Malthus, An essay on the principle of population, in: St. Paul's Church-Yard, 1798. London: J. Johnson.
[3] R.J. Barro, G.S. Becker, Fertility choice in a model of economic growth, Econometrica 57 (2) (1989) 481–501.
[4] P.M. Romer, Increasing returns and long-run growth, J. Polit. Econ. 94 (1986) 1002–1037.
[5] G.S. Becker, H.G. Lewis, On the interaction between the quantity and quality of children, J. Polit. Econ. 81 (2) (1973) 279–288.
[6] N.E. Borlaug, I. Narvaez, O. Aresvik, R.G. Anderson, A green revolution yields a golden harvest, Columbia J. World Bus. 4 (3) (1969) 9–19.
[7] Ministry of Food and Agriculture, Annual report, Retrieved Minist. Food Agric. Inform. Dir. 1 (2014) 1–161.
[8] Ministry of Food and Agriculture, Agriculture in Ghana: Facts and Figures, 2016, 2016 (Retrieved from).
[9] IFPRI, Pattern of Adoption of Improved Rice Technologies in Ghana (Ghana Strategic Support Programme), vol. 35, 2013, p. 36. http://www.ifpri.org/publication/patterns-adoption-improved-rice-technologies-ghana.
[10] Ministry of Food and Agriculture. (2017). 2017 Agricultural progress report - ministry of food & agriculture. Retrieved from ministry of food and agriculture: mofa.gov.gh/ … /2018/ … /MoFA%202017%20AGRICULTURAL%20PROGRESS%20R.
[11] A.F. Alidu, M. Tanko, A. Iddrisu, Factors enhancing smallholders Farmers' access to masara N'arziki project in the northern region of Ghana, Int. J. Dev. Res. 6 (10) (2016) 9609–9615.
[15] M. Tanko, S. Ismaila, S.A. Sadiq, Planting for Food and Jobs (PFJ): a panacea for productivity and welfare of rice farmers in Northern Ghana, Cogent Econ. Finance (7) (2019) 1–14, 1693121.
[16] E. Donkor, Determinants of Resource Use Productivity and Efficiency of Ghana's Rice Industry, The University of the Free State, 2015.
[17] U. Kushwaha, S. Khatiwada, H. Upreti, U. Shah, D. Thapa, N. Dhami, S. Sah, Modification of rice breeding technology in the 21st century, Int. J. Bioinf. Biomed. Eng. 1 (2) (2015) 77–84.
[18] N. Uphoff, A.K. Thakur, An agroecological strategy for adapting to climate change: the system of rice intensification (SRI), in: Sustainable Solutions for Food Security, Springer, Berlin, Germany, 2019, pp. 229–254.
[19] S.J. Salm, T. Falola, Culture and Customs of Ghana, Greenwood Publishing Group, Westport, United State, 2002.
[21] A. Rubio, *Factors That Impact Girls' Education In Ghana:The Role of Cultural Mind-Set.* (Master of Education and Leadership), Vancouver Island University, 2018. Retrieved from, https://viurrspace.ca/bitstream/handle/10613/6204/Rubio.pdf?sequence=1&isAllowed=y.
[22] S. Asuming-Brempong, K. Gyasi, K. Marfo, A. Diagne, A. Wiredu, A.A. Boakye, B. Frimpong, The exposure and adoption of New Rice for Africa (NERICAs) among Ghanaian rice farmers: what is the evidence? Afr. J. Agric. Res. 6 (27) (2011) 5911–5917.
[23] A.K.K. Bruce, Improved rice variety adoption and its effects on farmers'output in Ghana, J. Dev. Agric. Econ. 6 (6) (2014) 242–248.
[24] C. Ragasa, A. Dankyi, P. Acheampong, A.N. Wiredu, A. Chapoto, M. Asamoah, R. Tripp, Patterns of adoption of improved rice technologies in Ghana, Int. Food Pol. Res. Inst. Work. Paper 35 (2013) 1–36.
[25] A. Coe, Considering religious and cultural aspects of food and agriculture when seeking to introduce or develop GMOs, AgBioforum 17 (2) (2014) 197–204.
[26] K. Lee, The Role of Culture in Agricultural Technology Diffusion in Ghana, MMSS SENIOR THESIS), 2011.
[27] J. Elster, Explaining Social Behaviour: More Nuts and Bolts for the Social Sciences, Cambridge University Press, 2015.
[28] E.L. Paluck, L. Ball, C. Poynton, S. Sieloff, Social Norms Marketing Aimed at Gender-Based Violence: A Literature Review and Critical Assessment, International Rescue Committee, New York, 2010.
[29] E. Durkheim, The Division of Labor in Society. Free Press, Google Scholar, New York, 1997, 1893.
[30] A.M. Polinsky, S. Shavell, The economic theory of public enforcement of the law, J. Econ. Lit. 38 (1) (2000) 45–76.
[31] J. Elster, Emotions and economic theory, J. Econ. Lit. 36 (1) (1998) 47–74.
[32] J. Elster, Social norms and economic theory, J. Econ. Perspect. 3 (4) (1989) 99–117.
[33] M. Weber, The Protestant Ethic and the Spirit of Capitalism, T. Parsons, *Trans*, Scribner, New York, 1930 (Original work published 1904).
[34] S. Spencer, Race and Ethnicity: Culture, Identity and Representation, Routledge, London, 2014, p. 366. Available at: Taylor & Francis Group, https://www.taylorfrancis.com/books/9780203519165.
[35] E.B. Tylor, Primitive Culture: Researches into the Development of Mythology, Philosophy, Religion, Language, Art and Customs, vol. 1, Murray, London, 1874.
[36] H. Winant, Race and race theory, Annu. Rev. Sociol. 26 (1) (2000) 169–185.
[37] M. Sherif, C.W. Sherif, Groups in Harmony and Tension; an Integration of Studies of Intergroup Relations, Harper & Brothers, Oxford, England, 1953.
[38] C. Geertz, M. Banton, Religion as a Cultural System, 1966. http://nideffer.net/classes/GCT_RPI_S14/readings/Geertz_Religon_as_a_Cultural_System_.pdf.
[39] B. Cislaghi, D. Gillespie, G. Mackie, Values Deliberation and Collective Action in Rural Senegal. Manuscript. University of California, Google Scholar, San Diego, 2014.
[40] A.M. Muñoz Boudet, P. Petesch, C. Turk, On Norms and Agency: Conversations about Gender Equality with Women and Men in 20 Countries: Human Development, World Bank. © World Bank, Washington, DC, 2013. https://openknowledge.worldbank.org/handle/10986/13818 License: CC BY 3.0 IGO.
[41] G. Mackie, F. Moneti, E. Denny, H. Shakya, What Are Social Norms? How Are They Measured, University of California at San Diego-UNICEF Working Paper, San Diego, 2012.
[42] A. Saha, Culture and the development of technology in Japan, Technol. Soc. 16 (2) (1994) 225–241.
[43] K.A. Abay, G. Blalock, G. Berhane, Locus of control and technology adoption in developing country agriculture: evidence from Ethiopia, J. Econ. Behav. Organ. 143 (2017) 98–115.
[44] M. Guerzoni, A. Jordan, Cursed is the ground because of you": religion, ethnicity, and the adoption of fertilizers in rural Ethiopia, Retrieved from, https://ideas.repec.org/p/uto/dipeco/201605.html, 2016.
[45] A.A. Djurfeldt, G. Djurfeldt, D.B. Sarpong, Community, cohesion and context: agrarian development and religion in Eastern Region, Ghana, Geoforum 52 (2014) 78–89.
[46] C. Bicchieri, Norms in the Wild: How to Diagnose, Measure, and Change Social Norms, Oxford University Press, 2016.
[47] C. Bicchieri, J.W. Lindemans, T. Jiang, A structured approach to a diagnostic of collective practices, Front. Psychol. 5 (2014) 1418.
[48] L.J. Savage, The Foundations of Statistics, John Wiley, New York, 1954.
[49] J. von Neumann, M. Oscar, Theory Games and Economic Behavior, Princeton University Press, *Princeton*, NJ, 1944.
[50] J. Quiggin, A theory of anticipated utility, J. Econ. Behav. Organ. 3 (4) (1982) 323–343.
[51] D. Kahneman, Maps of bounded rationality: psychology for behavioural economics, Am. Econ. Rev. 93 (5) (2003) 1449–1475.
[52] W.A. Clark, W. Lisowski, Prospect theory and the decision to move or stay, Proc. Natl. Acad. Sci. USA 114 (36) (2017) E7432–E7440.
[53] M.J. Best, R.R. Grauer, Prospect theory and portfolio selection, J. Behav. Expe. Finance 11 (2016) 13–17.
[54] M. Tanko, S. Ismaila, How culture and religion influence the agriculture technology gap in Northern Ghana, World Dev. Perspect. 22 (2021), 100301.
[55] M. Tanko, Is farming a belief in Northern Ghana? Exploring the dual-system theory for commerce, culture, religion and technology, Technol. Soc. 63 (2020), 101339.
[56] M. Tanko, Technology Adoption, Technical Efficiency, and the Welfare of Rice Farmers in Northern Ghana, The University of Newcastle, Australia, 2021.
[57] J.O. Gakpo, Ghana's Christian Leaders Join GMO Debate, with Some Vouching for the Technology's Goodness, 2019. Retrieved from, https://allianceforscience.cornell.edu/blog/2019/07/ghanas-christian-leaders-join-gmo-debate-vouching-technologys-goodness/.
[58] Ghana Statistical Service, Regional Analytical Report, Northern Region. Retrieved from Ghana, 2013.
[59] Food and Agricultural Organisation, Country Statistics, 2018. Retrieved from, www.fao.org/faostat/eng/data.

[60] K.D. Ibrahim, Exploring the Cultural Conceptualisations and Understandings of Child Fostering and the Concept of the Child's Best Interests Among the Dagomba of Northern Ghana, 2015. https://www.era.lib.ed.ac.uk/handle/1842/33296.
[61] D.M. Levy, K. Padgitt, S.J. Peart, D. Houser, E. Xiao, Leadership, cheap talk and really cheap talk, J. Econ. Behav. Organ. 77 (1) (2011) 40–52.
[62] L.M. Lekhanya, Cultural influence on the diffusion and adoption of social media technologies by entrepreneurs in rural South Africa, Int. Bus. Econ. Res. J. 12 (12) (2013) 1563.