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Factors Influencing the Adoption of Climate Change Adaptation Strategies by Smallholder Farmers in East Mamprusi District of Northern Region, Ghana.

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Abstract

This paper looks at the factors that influence adoption of adaptation strategies by smallholder farmers in the East Mamprusi District of Northern Ghana. Ghana's economy is based mainly on rainfed agriculture and the smallholder farmers constitute the majority of the players in the sector. The rainfed nature of agriculture makes the farmers, including those in East Mamprusi District, vulnerable to the impacts of climate change. Farmers in the district have adopted climate change adaptation strategies to enable them survive the adverse impacts of climate change. In all, 250 farmers from 25 communities in 5 Area Councils were randomly sampled for the study. Data were collected using semi-structured questionnaire and analysed using frequencies, percentages, means, standard deviations and the probit regression model. The results indicate that planting crops late, use of soil and water conservation practices, mixed farming and mixed cropping are the major adaptation strategies adopted by the farmers in the district. The best predictors of choice of climate change adaptation strategies are formal education, extension contact, support, reduced meals, ease of technology use and food insecurity.

Keywords: *Climate change, Adaptation strategies, Smallholder farmers, East Mamprusi District.*

INTRODUCTION

Climate variability and change have become a global phenomenon that continues to affect the very survival of man, especially those whose livelihoods depend so much on rainfed agriculture. According to the UNFCCC (2007) climate change has effect on the environment and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity and coastal zones. One of the key elements of climate that is affected by climate change is rainfall, a very important factor in agriculture, especially developing countries. The UNFCCC (ibid) states that changes in rainfall pattern can result in severe water shortages (drought) and /or flooding. Lobell et al. (2008) have stated that the potential effects of climate change on agriculture have revealed Africa to be the most vulnerable continent to climate change. Nellemann *et al*. (2009) have indicated that Africa's vulnerability to climate change is due to the region's very low coping and adaptive capacity. The IPCC WG II (2007) has also reiterated the fact that Africa is one of the most vulnerable continents to environment change and climate variability because of

multiple stress and low adaptive capacity. Included in the category of vulnerable people are smallholder farmers who rely mainly on crop production.

Brown and Crawford (2008) posit that environmental change emerging through the driver of climate change could inflict harsh and extreme environmental conditions on rural smallholder farmers by reducing the poor households' livelihood options, particularly the agriculture sector. Such effects on livelihood options could worsen the existing patterns of poverty and undermine attempts towards poverty alleviation and improvement in household well-being. To survive these adverse effects of climate change farmers have used various adaptation strategies for centuries. Adaptation entails adopting the right measures to reduce the negative effects of climate change or taking advantage of the opportunities climate change affords by making the appropriate adjustments and changes. The adaptation options include technological, behavior change at the individual level, early warning systems, better water management, insurance and biodiversity conservation (UNFCCC, 2007). The IPCC (2007) also posit that adaptation options include behavioural, technological, regulatory, institutional and financial adaptation measures. According to Nhemachena and Hassan (2007) most commonly cited adaptation methods in literature include the use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed crop livestock farming systems, changes of planting dates, diversification from farm to non-farm activities, increased use of water and soil conservation techniques, and trees planted for shade and shelter. Yong (2013) is of the view that individuals, groups within society, organisations and governments make decisions on the type of adaptation on behalf of society. Differences exist in adaptive measures households use in response to climate change because of their ease of implementation, equity effects, lag between implementation and effect, their cost of implications, compatibility with other programs, and agencies' implementing measures (Admassie, 2008). Yong (2013) identified adaptation methods used by farmers in Cameroun to be soil conservations, different crop varieties, early and late planting, planting trees and irrigations.

The economy of Ghana depends mainly on agriculture and the smallholder farmers are major players in the sector. These farmers account for about 80% of domestic production and depend mainly on rainfed agriculture and this makes them vulnerable to the impacts of climate change. The rainfall pattern is highly variable both within and between years, especially in the northern part of the country. According to the Ministry of Environment, Science and Technology (MEST, 2012) temperatures have risen across the various ecological zones in Ghana whereas rainfall pattern is becoming less predictable.

Northern Ghana is particularly hit by the adverse effects of climate change and variability. The region falls within the Sudan Savannah ecological zone and is prone to frequent variability in rainfall, frequent droughts and floods and increased temperatures (Obeng, 2014). These situations have affected agriculture adversely with the resultant reduction in soil moisture and subsequent reduction in crop yields (Dietz *et al*, 2004; Obeng, 2014). Coping strategies used by smallholder farmers in the past have become increasingly unworkable because of increasing frequency and intensity of climate change and variability. In the face of increasing vulnerability the farmers have adopted adaptation strategies that are helping them to survive the impacts. According to Demeke (2003), adoption studies relate to use or non-use of a particular technology by individual farmers at a point in time, or during an extended period of time. Thus adoption presumes that the technology exists and adoption process analyses the determinants of whether and when adoption takes place (Colman and Young, 1989). This study therefore conceptualized adoption as the

continuous use of a technology over an extended period of time.

In their study in Northern Ghana, Etwire *et al*. (2013) identified the following as some of the adaptation strategies introduced to farmers; high yielding, drought tolerant and early maturing crop varieties, inorganic fertilizers and compost, harrowing, row planting and conservation agriculture. They also found out that sex of household head, age of household head, total farm size, noticed unpredictable temperature and agro-ecology were the factors that significantly influenced farmers' adoption of the strategies introduced. Mabe *et al*. (2014) also identified changing planting dates, changing crop varieties, fallowing, diversification, fertilization, mulching and soil conservation as some of the climate change adaptation strategies farmers have adopted in Northern Ghana. This paper therefore looks at the factors that influence the adoption of adaptation strategies by farmers in the East Mamprusi District of Northern Region of Ghana.

MATERIALS AND METHODS

The study was carried out in the East Mamprusi District of the Northern Region of Ghana. The district is located in the north-eastern corner of the region. Food production in the district has not been very consistent in recent times and this is attributed to declining soil fertility, high cost of farm inputs, poor distribution of rains, lack of irrigation schemes for dry season farming and high rate of illiteracy among others.

The population for the study comprised smallholder crop farmers in the district. In all 250 farmers from 25 communities in 5 Area Councils, namely, Gambaga, Langbinsi, Nalerigu, Gbintiri and Sakogu were randomly sampled for the study. The 250 farmers comprised 10 from each of the 25 selected communities. Semi-structured questionnaire was used to collect data. The individual respondents were interviewed using the questionnaire. A five point Likert scale was used to measure the extent to which farmers agreed with statements relating to the adoption of specified adaptation strategies. The scale ranged from 1 = Strongly Agree to 5 = Strongly Disagree. The complete scale is indicated as: 1 = Strongly Agree (SA), 2 = Agree (A), 3 = Somewhat Agree (SA), 4 = Disagree (D) and 5 = Strongly Disagree (SD).Data analysis involved the use of means and standard deviations, frequencies and percentages and probit regression model.

In response to climate change some farmers have adopted some strategies to survive the effects. This study specifically focuses on adaptation strategies which are long term and have been practiced over an extended period of time. Adoption as defined by Sahin (2006) is the decision to fully use or employ an innovation as the best course of action available. This study defined adoption following this definition and this was used to help categories farmers into adopters and non-adopters. In the design of the study, this was carefully considered. There were specific questions that afforded the farmers the opportunity to indicate whether they have adopted a set of practices or not over a period of time. This process led to the segregation of farmers into adopters and non-adopters. This then allowed the use of a probit model to estimate the factors influencing the adoption of climate change adaption strategies.

The model for the probit regression is specified below as:

Where:

$$P(y=1/x)=\beta_o+\beta_1X_{_1}+\beta_2X_2+\beta_3X_3+....\beta nXn+U$$

y is the 0-1 outcome with 1 corresponding to an individual adopting climate change adaptation strategies and 0 corresponding to an individual not adopting climate change adaptation strategies.

X_1-X*n* correspond to sets of socio-demographic, technology and institutional factors, respectively.

β_o =intercept of the function

β_1-βn are coefficients,

U is the error term which is assumed to follow a standard normal distribution with mean zero and variance 1.

The regression equation is stated thus:

$$y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \beta_{14}X_{14}$$

Where X_1 = Age; X_2 = Sex; X_3 = Marital status; X_4 = Formal education; X_5 = Extension contact; X_6 = Support; X_7= Technology; X_8 = Social status; X_9 = Belief system; X_{10} = Health status; X_{11} = Reduced meals; X_{12} = Ease of technology use; X_{13} = Land ownership; X_{14} = Food insecurity

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Table 1: Description of Variables used in the Probit Regression

Variable	Description	Measurement
Dependent variable		
Adoption	Adoption of climate change adaptation strategy (dummy)	1 = adoption, 0 = otherwise
Explanatory variables		
Age	Age of respondent	No. of years of respondent
Sex	Sex of respondent (dummy)	1 = Male; 0 = Female
Marital status	Marital status of respondent (dummy)	1 = Married; 0 = Otherwise
Formal education	If respondent has formal education (dummy)	1 = Formal education; 0 = Otherwise
Extension contact	Individual receives extension contact (dummy)	1 = Yes; 0 = Otherwise
Support	Government/private support influences adoption of strategy (dummy)	1 = Yes; 0 = Otherwise
Technology	Type of technology influences adoption (dummy)	1 = Yes; 0 = Otherwise
Social status	Whether social status influences adoption (dummy)	1 = Yes; 0 = Otherwise
Belief system	Whether belief system influences adoption (dummy)	1 = Yes; 0 = Otherwise
Health status	Health status of HH head influences adoption (dummy)	1 = Yes; 0 = Otherwise
Reduced meals	Household members have reduced number of meals per day (dummy)	1 = Yes; 0 = Otherwise
Ease of technology use	Ease of using technology influences adoption (dummy)	1 = Yes; 0 = Otherwise
Land ownership	System of land ownership influences adoption (dummy)	1 = Yes; 0 = Otherwise
Food insecurity	Household is food insecure (dummy)	1 = Yes; 0 = Otherwise

RESULTS AND DISCUSSIONS

Demographic Characteristics

The ages of the respondents range from less than 20 years to more than 60 years. This is indicated in table 2 below. The majority of the respondents engaged in farming (68%) are youthful and their ages range from 20 to 40 years. The greater majority (89.2%), constituting the economically active group fall within the age group of 20 to 50 years. The mean age of the respondents is 38 years. A crosstab between age and adoption of adaptation strategies indicated that 77.4% of the respondents who fall between 20 and 49 years have adopted adaptation strategies in the district. This shows that younger farmers are more inclined to adopt the strategies than the older ones. This may be due to the strenuous nature of

the activities involved in the implementation of technologies that enable farmers to adapt to climate change. This is in line with the findings of Dolisca *et al*. (2006) who found out that age is significantly and negatively related to farmers' decisions to adopt soil and water conservation and forestry management programmes respectively. In other words as farmers get older they are less inclined to adopt technologies. Shongwe, Masuku and Manyatsi (2014), however, found in their study carried out in Swaziland that age of household heads significantly influenced adoption of adaptation strategies positively.

The respondents who are married form 77% whilst the single ones form 14% as shown in table 2.The fact that majority of the respondents are married is indicative of the fact that family labour could be available for carrying out adaptation strategies that will enable the family to survive the effects of climate change. The married ones rely mainly on family labour to carry out farming activities. A cross tabulation of marital status and adoption of adaptation strategies revealed that as many as 188 (77.4%) married respondents have adopted climate change adaptation strategies to enable them survive the climate change effects. Mandleni and Anim (2011) found married livestock farmers to be more aware and adapted to climate change in South Africa.

Out of the 250 respondents, 39% had no formal education, while the remaining 61% achieved a certain level of formal education. See table 2. The 61% who have attained certain levels of formal education, are capable of benefiting from capacity building and training in adaptation strategies so as to improve their resilience to climate change. Compared to the northern region as a whole with literate population of 37.2% it can be said that the attainment of formal education in the district is high. The 61% is, however, lower than the national literate population of 74.1% (GSS, 2013). The district was the first headquarters of the Northern Territories and this necessitated the building of educational infrastructure and institutions to provide basic literacy in the area by the colonial government. The relatively high literate population of the adult population could be attributed to the establishment of the educational institutions. The existence of these institutions has made formal education accessible to the majority of the people. High literacy rate is known to positively influence the adoption of agricultural technologies and climate change adaptation decision. See Deressa, Hassan, Alemu, Yesuf and Ringler (2008), Nkonya *et al*. (1997) and Maddison (2006).

Table 2: Demographic Characteristics of Respondents

Characteristic	Frequency	Percentage
Age		
21-30	81	32.4
31-40	89	35.6
41-50	53	21.2
51-60	24	9.6
61 and above	3	1.2
Sex		
Male	125	50
Female	125	50
Marital Status		
Married	192	77
Single	35	14

Separated	7	3
Widowed	16	6
Education		
Formal Education	152	61
No Formal Education	98	39

Adaptation strategies used by households in response to climate change

Table 3 presents adaptation strategies adopted by farmers in response to the effects of climate change. The results show that about 44% of farmers have adopted these adaptation strategies. However, the results below reflect the opinions of only those farmers who have adopted the strategies.

Table 3: Adaptation strategies used in response to climate change

Strategy	Mean	SD
Household resorted to dry seasons gardening	3.99	.91
Household plant different crops	3.13	1.19
Household now plant crops late	1.97	.84
Household engage in off-farm activities	3.85	1.01
Household now use fertilizer and pesticides on the farm	1.61	.75
Household uses soil and water conservation practices	2.06	.72
Household practice mixed farming	2.28	1.09
Household engage in mixed cropping	2.31	1.07
Household practice land rotation	3.25	1.22
Household farm along river banks	3.92	.91
Household plants leguminous trees on farm	3.93	.98
Household plants cash crops (cotton, tobacco, cashew)	3.63	1.15
Mean of Means	**2.99**	**0.99**

Scale: 1 = Strongly Agree (SA); 2 = Agree (A) 3 = Somewhat Agree (SA) 4 = Disagree (D) 5 = Strongly Disagree (SD)

The mean of means value of 2.99, approximately 3.0 with an SD = 0.99 as indicated in Table 3, corresponds to the "Somewhat Agree" response category on the scale. This means that the respondents have adopted some adaptation strategies to help them deal with the effects of climate change. The mean values range from 1.61, SD = 0.75 (Household now use fertilizer and pesticides on the farm) to 3.99, SD = 0.91 (Household resort to dry seasons gardening).This implies that households use fertilizer and pesticides most and dry season gardening least. A mean value of 3.99 for dry season gardening is approximately 4.00 and is equivalent to "Disagree" on the scale. The resort to the use of fertilizer and pesticides as the most important adaptation strategy is not out of place because of the decline in soil fertility and an increase in pest and disease infestation on crops and animals due to climate change.

The results further indicate that the following adaptation strategies have been adopted by farmers in response to climate change/variability: planting crops late (1.97, SD = 0.84), use of soil and water conservation practices (2.06, SD =0.72), mixed farming (2.28, SD =1.09) and mixed cropping (2.31, SD = 1.07). The mean values for all these strategies correspond to the "Agree" response category on the scale. This means that these are

strategies farmers in the district have adopted in response to the effects of climate change. This is in line with Yong (2013) who found out in Cameroon that adaptation methods used by farmers included soil conservations, planting different crop varieties, early and late planting, planting trees and irrigations. See also Mabe et al. (2014) who found out in northern Ghana that farmers have resorted to changing planting dates, changing crop varieties, fallowing, diversification, fertilization, mulching and soil conservation as some of the adaptation methods in response to climate change. The respondents "Somewhat Agree" with the fact that they plant different crops (3.13, SD = 1.19) and practice land rotation (3.25, SD = 1.22). This means that they use these strategies less compared to the others. All the remaining strategies recorded mean values of approximately 4.00, meaning that they disagree with these statements and therefore do not use these strategies in response to climate change or variability. In percentage terms 41.7% of the adaptation strategies are practiced by the respondents while another 41.7% is not practiced. The remaining 16.6% of the strategies are practiced to some extent by the farmers. Uddin, Bokelmann and Entsminger (2014) also identified crop diversification, crop rotation, cultivating short duration crops, use of drought tolerant varieties, engagement in non-farm activities and soil conservation practices as some of the strategies farmers in Bangladesh have adopted towards climate change adaptation.

Determinants of adoption of climate change adaptation strategies

A probit model was used to estimate the factors that determine the adoption of climate change strategies. From the results in table 4, the adoption of adaptation strategies by smallholder farmers is determined by formal education, extension contact, government/private support, reduced meals, ease of technology use, and food insecurity. Among these variables, formal education, extension contact, reduced meals, ease of technology use, and food insecurity were positively related to adoption of climate change adaptation strategies while government/private support was negatively related.

Table 4: Determinantsof adoption of climate change adaptation strategies

Variable	Marginal Effects	Robust Standard Errors
Age_ respondent	0.0014	0.0023
Sex	-0.0308	0.0431
Marital status		-0.0096
Formal education	0.1066**	0.0527
Extension contact	0.5458***	0.0884
Support	-0.1150**	-0.1150**
Technology	-0.0572	-0.0572
Social status	-0.0438	-0.0438
Belief system	-0.0287	-0.0287
Health status	0.0883	0.0883
Reduced meals	0.1763***	0.0370
Easy technology	0.1240**	0.0475
Land ownership	-0.0744	0.0426
Food insecurity	0.1431**	0.0749
Log pseudo likelihood	-74.4889	
Wald χ^2 (14)	93.98	
Prob> χ^2	0.000	
Pseudo R^2	0.4290	
Observations	250	
Log pseudo likelihood		

Note: *, ** and *** are levels of significance at 10%, 5% and 1%, respectively.

Formal education and adaptation strategies

From the results in table 4 above, having formal is positively related to adoption of climate change adaptation strategies and is significant at 5%. From literature, it is expected that farmers who had formal educational are more likely to adopt climate change adaptation strategies as compared to those without formal education. The results support the findings of Deressa *et al*.(2008), Doliscaet al. (2006), Maddison (2006) and Anim (1999) that education increases ones' ability to receive,

decode, and understand information and this positively influences farmers' adoption of climate change adaptation strategies. Ervin (1982) also found education to have positive influence on the adoption of agricultural technologies. Others have, however, found education to influence adoption negatively (Lapar and Pandey, 1999; Okoye, 1998). Higher education influences adoption decisions because it is associated with the ability to synthesize more information on climate change adaptation strategies on offer and improvement of farm management. Farmers with higher level of education have an enhanced ability to understand and interpret information regarding adoption of climate change adaptation strategies. The marginal effect shows that having formal education increases the probability of adopting adaptation strategies by 0.1066 or about 11%. This may be the case because farmers who do not have formal education may not have fair knowledge of factors that increase the productivity of crops as compared to their counterparts with formal education.

Extension contact and adaption strategies

The results in table 4 reveal that, extension contact is positively related to adoption of climate change adaptation strategies and is significant at 1%. This means that farmers that had contact with extension agents are more likely to adopt climate change adaptation strategies as compared to those who had no contact with extension agents. The marginal effect shows that farmers who had contact with extension agents have higher probability of adopting adaptation strategies by 0.5458. The marginal effect for this variable was the highest of all the variables specified in the model and it shows how important extension contact or service is to the farmers. Farmers who had access to extension agents tend to have access to relevant information which helps them to make informed decisions on adoption of climate change adaptation strategies. Hence, household heads who receive extension services are more likely to adopt climate change adaptation strategies than their counterparts who do not receive extension services. This finding is in line with the findings of Gbetibouo (2009), Anley, Bogale, Haile and Gabriel (2007), Nhemachena and Hassan (2007), Tizale (2007), Maddison (2006) and Bekele and Drake (2003). Government/private Support *and adaptation* strategies.

From the results in table 4 above, government/private support is negatively related to adoption of climate change adaptation strategies at 5% significant level. The implication of this is that farmers who receive support from government/private sector are less likely to adopt climate change adaption strategies. The marginal effect of -0.1150 gives the indication that farmers who receive support had decreased probability of adoption by 0.1150 and thus the probability of a farmer adopting climate change adaptation strategies decrease by 0.1150 or about 12%. This means that farmers who receive support (either in kind or in cash) from public or private organisations are less likely to adopt climate change adaptation strategies than their counterparts who do not receive any support. The support that comes to farmers during periods of extreme climate events is more in the form of relief items or food aid instead of improved seeds and fertilizers. These forms of support are usually not very helpful to the smallholder farmers with respect to production. Though the food aid helps in providing food for the household it does not contribute directly to the production processes of the farm family, hence the negative relationship between support and adoption of adaptation strategies. The result is contrary to the *a priori* expectation that support provided to farmers will positively affect their climate change adaptation strategies adoption.

Reduced meal intake and adaption strategies

As expected, the results have indicated positive and highly significant relationship (coefficient of 0.1763 at 1% significance level) between reduction in meals intake and adoption of climate change adaptation strategies (See table 4). What this means is that farmers who experienced reduced meals intake are more likely to adopt climate change adaptation strategies as compared to their colleagues who are food secured. The marginal effect shows that the probability of adopting climate change adaption strategies increases by 0.18 or 18% for those who had reduced meal intake. This suggests that, in the midst of serious food scarcity and insecurity, households that reduce their meals intake, either by reducing the quantities eaten or the number of times they eat in a day are more likely to adopt climate change adaptation strategies as compared to those having more food to eat. Reduction in food intake as a result of climate change is due to inadequate food for the family and this has an ultimate effect on the nutrition of the family and hence the health of the family, especially the children. Not only does the quantity of food reduce, the quality of the food eaten is also affected adversely.

Ease of technology use and adaption strategies

The results in table 4 indicate that the ease with which one can use a technology increases the probability of adopting a climate change adaptation strategy. Farmers will adopt climate change adaption practices that are easy to use. The coefficient was positive and significant at 5%. The ease of using a technology increases the probability of adopting adaptation strategies by 0.1240 or about 12%. This means that though access to technology is important, the ease with which that technology can be used is paramount. A technology that is easy to understand and use is more friendly and acceptable to farmers and thus enhances adoption than one that is complex. Farmers who view the use of the technology as easy would be expected to have a higher level of adoption whereas those viewing the technology as difficult to use would be expected to have low level of adoption or no adoption at all. Rogers (2006) contended that the more complex or the more difficult an innovation or a technology is to understand and use, the less likely it will be adopted. Again the finding is in line with Admassie (2008) cited in Blessing *et al*. (2003) who indicated that the adaptive measures employed by households to adapt to climate change is influence by the ease of implementation, cost of implementation, compatibility with other programs, and agencies implementing measures.

Food insecurity and adaptation strategies

As expected, households which are food insecure are more likely to adopt the strategies compared to food secured households. Table 4 shows that food insecurity and adoption of climate change adaptation strategies are positively related and the relationship is significant at 5%. The marginal effect of 0.1431 implies that the probability of food insecure households adopting adaptation strategies increases by 14%. This means that the more food insecure a household is, the more likely the household is to adopt climate change adaptation strategies. The adaptation of these strategies will lead to increase in yield and will ultimately make the household more food secure.

CONCLUSIONS

In response to climate change variability, about 44% of farmers have adopted climate change adaptation strategies towards reducing the impacts of climate change. The most widely used adaptation strategies by farmers are planting crops late, use of soil and water conservation practices, mixed farming and mixed cropping. Other strategies used less by farmers are planting different crops and land

rotation. These adaptation strategies adopted by farmers in response to climate change/variability in the study area are helping to improve productivity, increase yield and reduce food insecurity in smallholder households. Factors influencing the adoption of climate change adaptation strategies include formal education, extension contact, government/private support, reduced meals, ease of technology use, and food insecurity.

RECOMMENDATIONS

Policies aimed at promoting smallholder farmers climate change adaptation strategies need to emphasize the critical role of providing relevant and timely support in the form of seeds, fertilizer and credit that will contribute directly to the production process instead of relief items and food aid. (through extension services) and the means to implement adaptations through easy understanding and use of technology.Scientists who develop agricultural technologies should do so in consultation with the farmers or potential beneficiaries to ensure compatibility with existing practices and enhance understanding and use of such recommended technologies.

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