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RURAL HOUSEHOLDS' PERCEPTION OF CLIMATE CHANGE IN THE CENTRAL AND NORTH GONDAR ZONES, NORTHWEST ETHIOPIA

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ABSTRACT

In the Central and North Gondar Zone, climate change is causing a challenge for smallholder farmers to improve their living standards. Rural communities face different climate change variables which negatively affect their livelihoods. Hence, this paper investigates rural households' perception of climate change, its determinants and their indigenous mitigation strategies in response to the perceived impacts of climate change. Both qualitative and quantitative data were collected through interviews, focus group discussions, key informant interviews and a review of different documents. To carry out the study, a multistage sampling procedure was employed. From each zone, study districts were selected purposively based on their economic activity and agroecological representativeness of the zone. A systematic sampling technique was employed to select 130 rural households. Primary data collected were analyzed by simple descriptive statistics and a logit regression model. The study results revealed that rural households did not similarly perceive climate change due to socioeconomic factors. Socioeconomic factors that significantly (at $p \leq 0.05$) determined rural households' perceptions of climate change were age, sex, educational status and access to extension services (at $p \leq 0.01$). The finding indicates that smallholder farmers used different indigenous mitigation strategies such as reforestation, minimizing deforestation, planting trees on their farmland and protection and tillage management practices for resolving climate change. According to the study, female-headed households participated less in agricultural training and had less access to information and restricted mobility outside the community to share information that help them to perceive climate change. Hence, equity issues should be considered for female-headed households and concerned bodies such as environmental protection experts and agricultural extension service providers should emphasize the upgrade of the farmer's capacity to mitigate climate change through indigenous knowledge for enhancing their living standard. In addition, development agents' facilitation of indigenous knowledge sharing among farmers should be emphasized to mitigate climate change.

Key words: Climate change, mitigation strategies, perception, respondents, rural

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INTRODUCTION

Climate change is a current human security issue that threatens the world's most vulnerable groups and property [1]. In Africa, it is one of the most detrimental factors, which affects rural households [2]. Climate change is adding some negative effects on the ecosystem in which rural communities live [3]. The effect varies based on the livelihood source and socioeconomic status of households, but it affects everyone in both current and future generations [4,5]. Rural farm households which are directly dependent on natural resources for their livelihoods are more vulnerable to climate change [3, 5, 6, 7, 8]. Particularly those households which engage in agricultural activities that are rain-fear the most vulnerable groups [9]. Climate change affects food production, distribution and consumption by households [10]. Hence, there should be an increase in agricultural production to meet the demand for food consumption [11]. Smallholder farmers are trying to develop the capacity to mitigate climate change but there is an alarming rate of change to resolve its effect [3].

Smallholder farmers have diversified views regarding climate change's effect on their agricultural production. They have perception differences in the trend of climate change based on their location and livelihood sources [9]. Rural communities have varying perceptions of climate change but Julia [9] did not identify socioeconomic determinants of perception variation on climate change. The response made by households toward climate change risk was influenced by the perception of climate change [12]. The farmers' perception of climate change depends on the source of information such as their counsel, fellow farmers and extension workers. Perceiving climate change through experience is the most paramount role [13, 14].

In Ethiopia, an investigation conducted by Tessema *et al.* [14] at East Hararghe Zone mainly focused on the sources of information on climate change and the perception of farmers on climate change but the authors did not identify determinants of perceptions on climate change. In addition, a study conducted by Kahsay *et al.* [15] at Semiarid Highlands of Eastern Tigray did not emphasize farmers' perception of climate change and its determinants.

Combining indigenous and scientific knowledge assists the community to increase healthy mitigation measures for climate change [16]. Hence, emphasis should be given to indigenous knowledge for climate change mitigation [17]. Traditional knowledge plays an immense role in human being development but it has been underutilized by science [18]. Hence, understanding their perception of climate

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change and their mitigation strategies is crucial to design and implementing an appropriate policy for vulnerable people. Therefore, the main objective of this study is to assess the rural households' perceptions of climate change concerning the determinants and indigenous mitigation strategies in response to climate change.

MATERIALS AND METHODS

Description of study areas

Ethiopia's topography is characterized by large regional differences, which are reflected in its climate. The lowlands in the northeast and southeast are tropical with mean temperatures ranging from 25-30°C, whereas the central highlands are much cooler having average temperatures of around 15-20°C. East African Rift Valley divides the highland plateau. It is habitat to nearly90% of Ethiopia's population [19]. Average annual rainfall ranges from less than 300 mm in the northwestern and southeastern lowlands to over 2,000 mm in the southwestern highlands [20].

The study was conducted in Northwestern Ethiopia in two zones namely the Central and North Gondar Zones. From the north Gondar zone Dabat district was selected while West Belesa district and Gondar zuria districts were selected from Central Gondar zone. In the study sites, the average rainfall ranges from 700mm to 1530mm. The altitude ranges from 1780m-2700m above sea level. The agroecology of the study area is characterized by lowland, midland and high land. Vegetation in the area varies from place to place. The southern part of the area is characterized by grassland with bush formation. Evergreen scattered woods exist in central, south and north of the study area. Plantation such as eucalyptus trees is common around Gondar town and other major towns of the area. The west low land areas and east of the study area are covered by deciduous woody vegetation. Mixed crop-livestock production is the dominant livelihood activity of smallholders in the areas [21].

Dabat district: Dabat district is one of the districts in north Gondar zone. It is bordered on the south by Wegera, on the west by Tach Armacho, on the northwest by Tegeda and the northeast by Debarq. The total population of this district is estimated to be 145,509 out of which 73,852 are male and 71,657 are female [22].

West Belesa district: West Belesa is one of the districts of central Gondar zone. It is among the chronically food insecure districts of the Amhara region. The district has 30 administrative kebles including Arbaya town, the capital city of the district. West Belesa is bordered on the south by LiboKemkem, on the west by Gondar

Zuria, on the East by East Belesa, and on the North by Wogera district. The total population in the district for the fiscal year 2016 was estimated to be 192,336 out of which 95,156 were male and 97,180 were female [23].

Gondar Zuria district: Gondar Zurya is one of the Central Gondar zone districts. Gondar zurya district has 35 rural kebeles and 2 urban kebeles. It covers an area of 142.08 km. It is bordered on the south by South Gondar zone, on the southwest by Lake Tana, on the west by Dembiya district, on the north by Lay Armachiho district, on the northeast by Wogera district and on the southeast by MirabBelesa district. It is estimated that a population of about 91,363 lives in the district [24].

Sampling procedure and sample size

The study employed a multi-stage sampling procedure. The first stage was a selection of the two zones from 13 zones in the Amhara region purposively, based on the mandate of the university, time and budget. The second stage is the purposive selection of three districts one from North Gondar and two districts from Central Gondar Zone based on the agroecology and socio-economic activities of the respondents. Between two Zones, three districts namely: Dabat (from North Gondar Zone), Gondar Zuria (from Central Gondar Zone) and West Belesa (from Central Gondar Zone) represent the highland (Dega), midland (Woina Dega) and lowland (Kolla), respectively. The third stage is the random selection of two villages from each district. In the fourth stage, systematic sampling techniques were employed to select 121 respondents proportionate to the size of the population of the rural farm households in the study area using the Yamane [25] sample size formula stated as Equation 1:

$$n = \frac{N}{1+N(e^2)} \text{---(1)}$$

Where:

n= Sample size, N= Population size from two zone and e= level of precision (0.09).

Therefore: $n = \frac{6786}{1+6786(0.09^2)} \approx 121.$

However, due to more heterogeneity of data collected from 121 respondents, additional information was required leading to the addition of nine more respondents. Thus, in Debat 48, Gondar Zuria 36 and West Belesa 46 respondents were taken. A total of 130 respondents were therefore sampled in the study.

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Data collection and analysis

Primary data: Since 2018, the primary data were collected by using different tools such as focus group discussion, key informant interviews, household interview schedules and observation. Focus group discussions and key informant interviews were held with community farmers and experts to collect information on the farmers' perceptions of climate change variables and indigenous climate change mitigation strategies. Six focus group discussions were held with farmers and three with experts. The total number of participants in each focus group was between8-13 individuals. Based on expertise there were two strata: farmers and government employees who were working in environmental protection offices, mainly climate change experts. In each stratum, there were 52 farmers and 31 experts. Additionally, farmers were also stratified based on gender (male and female) to reduce information distortion or to enhance free communication during discussion. Nevertheless, the number of female participants at FGD was less than male participants because of availability. A total of 83 individuals participated in FGD with 23 of them being females. Moreover, 26 individuals who know the community and surroundings were interviewed as key informants.

The sample household interview schedule was designed to collect primary data. The main primary data types collected include different socioeconomic variables, climate change variables and indigenous mitigation strategies. Data collected through the household interview were both qualitative and quantitative. Whereas data collected through focus group discussions, key informants and observation were more qualitative. The data collected through observation was a simple inspection of different landscapes used to mitigate climate change impact and the construction of their houses to resolve climate change hazards. Hence, it was used for triangulation of data collected through interview schedules, key informant interviews and focus group discussions.

Secondary information: information related to the location, total population and agroecology of the district were collected from the district and zonal agricultural offices. To supplement data obtained from primary sources, published and unpublished secondary documents on the general pattern of climate change, farmers' perceptions, and indigenous climate change mitigation strategies were reviewed.

Data analysis: Quantitative data were analyzed through simple descriptive statistics and an econometric model whereas qualitative data were analyzed through narration. In the descriptive part of the analysis, minimum, maximum, mean, standard deviation and percentage were used to analyze data quantitatively. The binary logit model was used to analyze farmers' perception of climate change using the Statistical Package for Social Sciences software (SPSS) version 25.

Econometric model

Probit and logit is the econometric model used to estimate dummy dependent variables [26]. However, the logit model is better than the probit model when there are many observations at the extremes of the distribution [27]. The dependent variable was the farmer's perception which took a value of 1 if the household perceived climate change and 0 if the farmer did not perceive it. Since farmers' perception of climate change is a categorical variable with binary outcomes, hence logistic regression was appropriate for analysis [29] (Table 1).

RESULTS AND DISCUSSION

Descriptive result of continuous variables

As shown in Table 2, the mean and standard deviation of the respondents' age was 45.8 and 14.7, respectively. The average family size was 5 with a minimum and maximum of 1 and 10, respectively. Households with more members faced the challenge of feeding their members owing to limited income-generating activity combined with climate change. The average land size owned by respondents was 0.8ha. They owned 2.5ha on maximum. Results of the study also revealed that there were respondents who do not have their plots of land. According to data collected through focus group discussions and key informant interviews, households that had no farmland were mostly youths. Resource (land and income) poor farmers had a limited number of livestock. Average and standard deviation of the frequency of weekly extension contacts was 2.1 and 1.4, respectively. However, some respondents had not made any contact to get an agricultural extension service. Farmers who were far from the main road and female-headed households were less and had no contact to get agricultural extension services. As a result, these categories of farmers were faced with challenges like accessing limited information on improved technologies for crop and livestock production and marketing.

Descriptive result of categorical variables

As indicated in Table 3, the number of males and females incorporated in the study was 80% and 20%, respectively. As indicated in the results, the total number of female participants was less than males due to less number of female-headed households. About 82% of the respondents were married, 12% divorced and 5% widowed. These results revealed that the majority of the respondents were found

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to be married. Among the respondents, 75% were illiterate. Respondents who had access to farming land and extension service were 89% and 30%, respectively. The result showed that the majority of respondents had access to farming land but less than half the number of farmers did not have access to extension services.

Rural households' perception of climate change

Results of the qualitative data collected through Focus Group Discussions (FGDs) and Key Informant Interview (KII) about farmers' perception of climate change revealed that climate change was influenced by livelihood sources, agro-ecology and gender, contact made with fellow farmers and extension agents. In line with this, a study conducted in tropical forests of Papua, Indonesia also revealed that household perception of climate change was influenced by gender, location, ecosystem and the experience of how their activity was affected [30]. As shown in Table 4, 57%, 19%, 7% and 17% of the respondents said that temperature was increasing, decreasing, no change and fluctuating, respectively. More than half of the respondents said that the temperature was increasing. In line with other authors, farmers perceived that there was an increase in temperature from year to year [14, 15, 31, 32,33]. Results from key informants and FGDs revealed that there was extreme cold temperature starting mid-October up to the end of January and hotness, especially during April. The respondents said that rainfall was increasing (25.4%), decreasing (36.2%), not changing (5.4%) and fluctuating (33.1%). The majority of respondents perceived that climate change was decreasing. In line with the finding of [15, 31, 32] farmers perceived a decrease in rainfall. Respondents perceived flood as increasing (36.9%), decreasing (23.8%), not changing (15.4%) and fluctuating (23.8%). Regarding frost, respondents perceived it as increasing (60.8%), decreasing (16.9%), not changing (3.1%) and fluctuating (19.2%) with different percentage levels. In addition, the respondents perceived drought as increasing (58.5%), decreasing (13.8%), no change (12.3%) and fluctuating (15.4%). Generally, respondents perceived that temperature, flood, drought and frost were increasing from day to day with decreasing trend of rainfall. Contrary to this finding, respondents perceived climate change as increasing flood and drought with the erratic nature of rainfall [33].

Based on the information collected through key informant interviews and focus group discussions, there was a negative change in livestock and crop production and productivity due to climate change. In addition, there was endemic disease occurrence and weed infestation on crops, which cannot be used for animal feed. The incidence of climate change is perceived in different ways. A farmer who is 65 years old from Gondar Zuria district of Central Gondar Zone, explained the changes he perceived by saying:

"The natural phenomena have completely changed as the rain is not coming in the expected time if any the amount and frequency varies from what we knew some years back. Flooding has become a common incidence; unknown weed types and crop diseases are also emerging. There is not enough pasture for livestock. In general, life in agriculture base is becoming complex and challenging."

Furthermore, the occurrence of dry wind (that is change in wind) also affects the crop at the maturity stage. Consequently, this change affects rural households' livelihoods negatively to improve their life. There was also a negative change in soil fertility, number of plants and wild animal species and surface and groundwater quantity and quality. According to the focus group discussion and key informant participants, the soil fertility and indigenous plants and wild animals were decreasing from time to time due to climate change. When the indigenous plant species decreased, there was migration and death of wild animals in the study areas. Especially during the winter season, there was also the problem of ground and surface water quality and quantity, which was used for drinking by humans and animals. Because of these climatic changes, the livelihood of the community becomes worse from time to time.

Determinants of farmer's perception of climate change
Logistic regression was employed to identify determinants of farmers' perception of climate change. To check the multicollinearity problems, contingency coefficient and variance inflation factor (VIF) was computed for dummy and continuous independent variables, respectively. The value of the contingency coefficient and variance inflation factor was less than 0.75 and 10, respectively. Hence, there was no multicollinearity problem. Hosmer and Lemeshow test was used to check for the goodness of model fit. The significance measure was 0.68 which is greater than 0.05, which indicated that the model fit the data very well. In addition, the Hosmer-Lemeshow test of goodness of fit also fails to reject the null hypothesis that the model fits the data well. Hence, the Hosmer and Lemeshow test statistic shows a significant association between the observed and the model's prediction of a household's perception of climate change. In the model, ten explanatory variables were included. Among the ten variables only age, sex, educational status and access to extension services were significant predictors of farmer perception of climate change (Table 5). The determinants were discussed in detail as follows:

Age: The result of the study indicated that the age of the respondents and their perception of climate change had a direct relationship and were significant at $P \leq 0.05$. Hence, as age increases, the perception of farmers toward climate change increases. It means that the elderly farmers recognized the climate changes better than a young farmers. This may be due to an increase in their experience and level of understanding of their surrounding environment because experienced farmers may have pertinent skills and adequate information about climate change. Similarly, most farmers perceived climate change through their life experiences [14]. Consistent with Falaki, Akangbe and Ayinde [12], the age of the respondents affected the perception of households on climate change positively. Moreover, the age of households has a positive coefficient and significantly affects the farmers' perception of climate change in line with Tesso, Emana and Ketema [34]. Data collected through key informants also indicated that old-age farmers had a better level of understanding of climate change.

Sex: The sex of the respondents was negatively related to a household's perception of climate change and significance (at $P \leq 0.05$) implying that male-headed households were better perceivers than female-headed households. This may be because male-headed households were better participants in agricultural training and had better access to information regarding climate change. From the information collected through focus group discussions and key informant interviews, male-headed households had better access to information regarding agricultural and climate-related issues due to better contacts made with development agents. Results of a study conducted by other investigators also indicated that there was a relationship between sex and households' perception of climate change [12, 34, 35]. That means male-headed households can acquire information on climate change, consequently affecting their climate change perception positively, compared to female-headed households.

Educational status: The educational status of the respondents is found to significantly ($P \leq 0.05$) affect farmers' perception of climate change. The result revealed that being illiterate had a negative relationship with the perception of climate change. This is because farmers who cannot read and write have less information related to climate change and less level of understanding of recent information. This finding is in line with the studies [12, 34] which also found that educational status has a significant and positive effect on the households' perception of climate change signifying that farmers who were educated were a better understanding of climate change than those who cannot read and write.

Access to extension service: According to the result, access to extension service had a positive relationship with the perception of households on climate change and was significant at $p \leq 0.01$. This implies there was a statistically significant association between access to extension services and farmers' perception of climate change. Hence, a household that has better access to extension services perceived better about climate change compared to their counters.

Rural households' indigenous climate change mitigation strategies
Smallholder farmers in the study area use deforestation (92%), conserving existing forest resources (99%) and planting a tree on their farmland (97%) to mitigate the change in temperature, rainfall, flood, drought, frost, soil fertility, wild animals, forest coverage and water availability. Reforestation is a practice made by farmers to increase forest coverage which is cut down for different purposes. In line with this Verchotet al (36] found that households used planting trees, forest management and better management of trees on croplands as mitigation strategies.

About 89% of the respondents used protecting soil conservation measures as a mitigation strategy. Nevertheless, the rest of the respondents did not take any remedial action for climate change variables. Protecting soil conservation measures were used for mitigating rainfall, wind, flood and drought. Soil and water structures were used for mitigating flooding, enhancing biodiversity and reducing sedimentation of waterways [37]. In addition, 92% of respondents used tillage management practices to mitigate soil fertility (Table 6). Tillage management especially zero tillage is one mitigation option for maintaining soil fertility as well as climate change by farmers in South Asia [38].

Most (86%) farmers utilized planting pulse crops through rotation as a mitigation strategy for frost, soil fertility change and crop production and productive-related changes. According to Matata *et al*. [39], farmers usually use legume plants to increase soil fertility. Conservation of grazing land is used to mitigate changes like floods, soil fertility and deforestation. Supplying alternative animal feed was reported to mitigate a decrease in livestock production. About 79% and 82% of the respondents used protecting grazing land and changing animal forage to resolve problems faced by them due to climate change, respectively. According to Sapkota et al (40) and Smith et al (41), improved manure management and feeding practices were used as a mitigation option for climate change induced by animal production. It was also reported that reserving extra food, weeding invasive weeds before flowering, environmental management, personal hygiene, and using traditional medicine for animal and crop pests are also climate change mitigation strategies (Table 6).

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CONCLUSION

Rural farm households in the study area perceived climate change as increasing, decreasing, no change and fluctuating with different percentage levels. The result of the research indicated that climate change variables such as temperature, rainfall, wind, flood, drought and frost affect rural households. Respondents' perception of climate change varied from household to household due to different socioeconomic factors. The major determinants, which affect households' perception of climate change: were age, sex, educational status and access to extension services. More than 90% of the respondents used indigenous mitigation strategies such as reforestation, conserving deforestation, planting trees and protection, and tillage management practices for mitigating climate change. As a result, they ease the negative effect of climate change on forestry, crop and livestock production and hence improve the livelihoods of farm households.

Perceiving the existence of climate change and recognizing the effect of climate change on smallholder farmers' life is the primary condition to undertake remedial action through mitigation strategies. Therefore, either government or non-governmental organizations should make favorable conditions for providing training and organizing awareness creation sessions on climate change as one of their intervention components for development. According to the study, female-headed households participated less in agricultural training, had less access to information and restricted mobility outside the community which help them to perceive climate change. Hence, equity issues should be considered for female-headed households regarding their social, economic, political and environmental development that help them to perceive and mitigate climate change's impact on their life. Concerned bodies such as environmental protection experts and agricultural extension service providers should emphasize upgrading the farmer's capacity to mitigate climate change through indigenous knowledge for enhancing their living standards. Moreover, indigenous knowledge mitigation strategies such as reforestation, planting a tree on their farmland, protecting soil conservation measures, tillage management practices and planting pulse crops should be promoted and development agents should facilitate farmer-to-farmer knowledge sharing.

Conflict of interest

The authors have not declared any conflict of interest.

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Table 1: Variables definition and a priori expectation for the households' perception of climate change

Dependent variable	**Measurement**	**A prior expectation**
Households perception of climate change	Dummy (1= if the household head perceived a change in climate, 2=Otherwise)	
Independent variable		
Age	Continuous (number)	-
Sex	Dummy (1 if male; 2= female)	-
Marital status	Categorical (1= Single, 2= Married, 3= Divorced, 4= Widowed)	±
Total family	Continuous (number)	+
The educational status	Dummy (1= literate, 2= no formal education)	+
Farm land ownership	Dummy (1= yes, 2= no)	+
Land size	Continuous in hectare	+
Livestock number	Continuous in Tropical Livestock Unit (TLU)	+
Access to extension service	Dummy (1= if the HH has access to extension service, 0=otherwise)	+
Extension contact	Continuous (number of days contact made weekly at the peak time of farming to get extension-related information)	+

Table 2: Descriptive result of continuous variables

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Age	130	20	78	45.8	14.7
Total family size	130	1	10	5.0	1.1
Land size (in ha)	130	0	2.5	0.8	0.6
Tropical livestock unit	130	0	16	3.5	3.0
Frequency of extension contact	130	0	7	2.1	1.4

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Table 3: Descriptive result of categorical variables

Variables	Items	Frequency	Percent
Sex	Male	104	80.0
	Female	26	20.0
Marital status	Married	107	82.3
	Divorced	16	12.3
	Widowed	7	5.4
Educational level	Illiterate	98	75.4
	Literate	32	24.6
Access to farming land	Yes	116	89.2
Access extension service	Yes	39	30.0
Perception of climate change	Yes	89	68.5

Table 4: Rural households' perception of climate change

Variables	Farmer's perception of climate change (in %)			
	Increasing (%)	Decreasing (%)	No change (%)	Fluctuating (%)
Temperature	56.9	19.2	6.9	16.9
Rainfall	25.4	36.2	5.4	33.1
Wind	49.2	15.4	11.5	23.8
Flood	36.9	23.8	15.4	23.8
Drought	58.5	13.8	12.3	15.4
Frost	60.8	16.9	3.1	19.2

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Table 5: Determinants of farmers' perceptions of climate change

Explanatory variables	Estimated Coefficients	Standard Error	P Value
Age	0.04**	0.02	0.02
Sex	-1.56**	0.75	.04
Marital status	0.69	0.52	0.18
Total family	-0.07	0.13	0.61
Educational status	1.51**	0.63	0.02
Farm land ownership	-1.04	0.95	0.27
Land size	-0.80	0.62	0.20
TLU	0.06	0.14	0.68
Access to extension service	3.59***	1.25	0.00
Extension contact	-0.26	0.19	0.18
Constant	-8.43	3.18	0.00

N=130
Chi-square =50.45***
-2 Log likelihood=111.62
Cox & Snell R Square=0.322
Nagelkerke R Square=0.451
Note: ** and *** refer to significance at p≤0.05 and p≤0.01, respectively.

Table 6: Descriptive result of rural households' use of indigenous climate change mitigation strategies

Variables	Affirmative Response	Frequency	Percent
Reforestation	Yes	120	92
Protecting deforestation	Yes	128	99
Protecting soil conservation measures	Yes	115	89
Planting pulse crops through rotation	Yes	112	86
Planting trees on farmland and protection	Yes	126	97
Tillage management practices	Yes	119	92
Protecting grazing land	Yes	103	79
Changing animal forage	Yes	107	82

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