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Article

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RESEARCH ARTICLE

The effects of improved maize technology on household welfare in Buruku, Benue State, Nigeria

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Abstract: This study was carried out to determine the welfare effects of improved maize technology in Buruku Local Government Area of Benue State, Nigeria. The study also examined the determinants of the adoption of improved maize technology. Structured questionnaires were used in collecting the primary data for the study. A multi-stage random technique was used in selecting 125 farm households for the study. The Logit and ordinary least square (OLS) models were used in analyzing the data. The OLS results show that adoption of improved maize varieties is positively and significantly related to household welfare and thus has contributed to moving farm households out of poverty. Other variables found to be statistically significant in explaining household welfare are education, household size, and landholding. The Logit results show that age, household size, off-farm income, and education were found to be significant in influencing farmers' adoption decisions. Some robustness checks were performed with different specifications of the Logit and OLS models as well as re-estimation with propensity matching score approach. Overall, the results are robust to different specifications.

Keywords: maize, improved technology, household welfare

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PUBLIC INTEREST STATEMENT

Agriculture is viewed as a strong option for enhancing economic growth, food security, and poverty reduction in Nigeria. This is because over 70% of Nigeria's labor force is employed in agriculture and depend on it for a living. This study analyzes the effect of improved technology on household welfare using maize, a major staple grain widely cultivated and consumed by majority of the Nigerians. Results show that households who adopted improved maize variety are more likely to have higher consumption expenditures. This is because higher incomes from improved technology translate to lower income poverty. Further analysis revealed that age, education, off-farm income, and household size are the major determinants of adoption of improved maize technologies. This calls for policy attention towards the provision and/or improvement of these factors, for enhancement of technology adoption, agricultural productivity, profitability, sustainability, and poverty reduction, in line with the 2008 World Development Report.

1. Introduction

Increased agriculture productivity is one of the strong options for stimulating economic growth, reducing poverty, and improving food security. In Nigeria for instance, agriculture is still the backbone of the economy despite her oil revenue. Agriculture contributes over 40% of Nigeria's GDP, employs over 70% of the population, and produces about 80% of the food needs (Aye, 2013). Although, agriculture still accounts for about 88% of non-oil export earnings, its contribution has seriously declined over the decade falling from about 75% of total export earnings in the 1960s to less than 3% currently (Oji-Okoro, 2011).

One of the main cereals cultivated, consumed, and marketed in Nigeria is maize. Maize is grown in all parts of Nigeria and it now forms part of the staple food in Nigeria. It contributes about 33% to the total household food consumption (Minot, 2010). Its importance has increased recently because of the federal governments' restriction on imported flour. Maize requires adequate rainfall for optimum yield. Annual rainfall of between 500 and 750 mm is adequate for maize production, although experiments (Fadama III project in Nigeria) have shown that a much lower annual rainfall can also sustain its growth. According to the profile of Fadama III project in Nigeria, Benue State has an annual average rainfall which varies from 1,200 to 1,500 mm annually. Maize is cultivated twice in Benue State, from March to April and September to October, because of the two distinct rainfall peaks. The fully grown maize attains about a height of 3–5 m and visible sign of the maturing maize plant is senesce. Seed rate of 2–3 seeds per stand at a depth of between 3 and 4 cm giving a seed rate of between 16 and 44 kg per hectare. When intercropped, the seed rate is normally less. Germination is 5–6 days after planting. Supplying which is carried out where there are missing stands in the field, is done a week after germination. Thinning takes place when the seedling is 3–5 cm tall. Maize is harvested green from 12 to 14 weeks if it is to be eaten fresh and 15–20 weeks when it is to be dried. Storage is done by shelling of grains and storing them in fumigating air tight containers, such as bins and earthen wares, then sealing them up to prevent insect pests from entering and also in bags after being treated with chemicals (Abimbola, Ademolo, & Udoh, 2000).

Nationally, less food is produced than required by most households. Thus, there is often a demand–supply gap arising from low productivity. "Theoretically, increasing the productivity of maize production would require either increased input use especially acreage expansion, improvement in resource use efficiency and or technological change derived from use of new technologies" (Aye, 2011). There is limited opportunity to increase productivity via agricultural land expansion due to the growing population (currently the Nigeria population is about or more than 150 million). Therefore, the country can only easily increase agricultural but maize productivity in particular by improving farm efficiency and through the introduction of improved maize technology. This current study focuses on improved maize technology and how its provision translates to welfare of farm households through affordable prices without compromising the natural environment and or resources for future generations.

Improved technologies such as hybrid seed, inorganic fertilizer, pesticides, herbicides, and better management practices constitute the basic activities for crop improvement. The Institute for Agriculture Research in Samaru Zaria, Crops Research Institute, Otobi, Benue State have designed programs for identifying and developing improved varieties that are high yielding, disease and pest resistant. The improved varieties combine the market and farmer-preferred traits (Shiferaw, Kebede, & You, 2008). Combinations of factors responsible for yield increase have been identified and they include; optimum plant density, fertilizer application rates, planting high yielding varieties, and improved control (Allen, 1968). The adoption of new technology is described as innovation–decision process through which an individual passes from the time of first hearing about an innovation (Allen, 1968).

The development and dissemination of improved maize seedlings is very costly. The justification for further investment in developing the technology is needed. Therefore, this study pursued two objectives which are (1) to investigate the factors that influence farmers' decision to adopt improved maize varieties and (2) to analyze the welfare impact of adopting improved maize varieties in Buruku local

government area of Benue State, Nigeria. There are only few studies on welfare and technology adoption (see Ali & Erenstein, 2013; Amare, Asfaw, & Shiferaw, 2012; Asfaw, Kassie, Simtowe, & Lipper, 2011; Asfaw & Shiferaw, 2010; Asfaw, Shiferaw, Simtowe, & Lipper, 2012; Becerril & Abdulai, 2010; Kassie, Shiferaw, & Muricho, 2011; Mendola, 2007; Minten & Barrett, 2008; Shiferaw et al., 2008) and these were mainly conducted for other countries. For instance, Asfaw and Shiferaw (2010) evaluated the potential impact of adoption of modern agricultural technologies on rural household welfare measured by crop income and consumption expenditure in rural Ethiopia and Tanzania. The study utilizes cross-sectional farm household level data collected in 2007 from a randomly selected sample of 1313 households (700 in Ethiopia and 613 in Tanzania). They estimated the casual impact of technology adoption by utilizing endogenous switching regression and propensity score matching (PSM) methods to assess results robustness. Their result reveals that adoption of improved agricultural technologies has a significant positive impact on crop income, although the impact on consumption expenditure is mixed.

Kassie et al. (2011) evaluated the ex-post impact of adopting improved groundnut varieties on crop income and rural poverty in rural Uganda. The study utilized cross-sectional farm household data collected in 2006 in seven districts of Uganda. They estimated the average adoption premium using PSM, poverty dominance analysis tests, and a linear regression model to check robustness of results. They result show that adoption of improved groundnut technologies has a significant positive impact on crop income and poverty reduction.

Amare et al. (2012) examined the driving forces behind farmers' decisions to adopt improved pigeon pea and maize and estimates the causal impact of technology adoption on household welfare using data obtained from a random cross-section sample of 613 small-scale farmers in Tanzania. They used the seemingly unrelated and recursive bivariate probit regressions to test the endogeneity and joint decision-making of pigeon pea–maize production. A double hurdle model was used to analyze the determinants of the intensity of technology adoption conditional on overcoming seed access constraints. To address the impact of adoption on welfare, they employed both PSM and switching regression techniques. The analysis of the determinants of adoption identifies inadequate local supply of seed, access to information, human capital, and access to private productive asset as key constraints for pigeon pea technology adoption. The causal impact estimation from both the PSM and switching regression suggests that maize/pigeon pea adoption has a positive and significant impact on income and consumption expenditure among sample households.

Ali and Erenstein (2013) estimate the impact of zero-tillage technology adoption on household welfare in Pakistan using cross-sectional data from 234 rice and wheat farm households. Results based on PSM approach indicate that adoption of zero-tillage technology has positive and significant impact on wheat yield and household income while non-significant impact on rice yields. Further, their result shows that adoption of zero-tillage technology can help to reduce poverty among rural households in the range of 8–10%. Therefore, the current study contributes by examining this relationship for Nigeria using Buruku local government area of Benue State as a case.

2. Methodology

The study was conducted in Buruku Local Government Area of Benue State which is positioned in the middle east of Benue State. Buruku local government is made up of 13 council wards namely: Mbatough, Etulo, Mbaade, Mbaakura, Binev, Mbakyongo, Mbayaka, Mbapen, Mbaazagee, Mbaatikyaan, Shorov, Mbaya, and Mbakyaan wards. It has an area of 1,246 km^2. The area has a monthly temperature between 27.38 and 28.00°C and may go up to a maximum temperature of 30.08 and 34.24°C. The area receives 9,000–1,000 mm of rain annually. The dry season starts in late October and usually ends by March (NIPOST, 2009) while the rainy season lasts from April to early October. Buruku LGA has a population size of population of 203,731 (2006 census). The indigenes of the areas are mainly Tivs and Etulo. They are engaged in farming crops like maize, yam, guinea corn, rice, sesame, and cassava which are the principal food crops and cash crops.

The sample for this study was drawn using a multi-stage random technique. Buruku is made up of 13 council wards. First, (5) wards out of 13 wards were randomly selected. Second, 25 maize farmers were randomly selected and interviewed from each of the five wards. This makes a total sample size of 125 maize farmers for the study. The study used mainly primary data. The primary data made use of both structured questionnaire and direct observation. Data were collected on the household size, age of household head, level of education, annual income, farm size, access to extension services and credit, membership of farmer organization, use of improved maize varieties, consumption expenditure, and among others.

Objective 1 was analyzed using the Logit model. The Logit model was estimated with maximum likelihood estimation technique. The Logit model for this study is specified as:

$$\frac{P_i}{(1-P_i)} = \frac{1+\exp(Z_i)}{1+\exp(-Z_i)} \tag{1}$$

Because Equation 1 is non-linear, one can linearize the model by taking the natural log. This gives the following linear Logit model:

$$Li = \ln\left[\frac{P_i}{(1-P_i)}\right] = Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_{11} X_{11} + e \tag{2}$$

where $\frac{P_i}{(1-P_i)}$ is the ratio of the probability that a farmer will adopt improved maize variety to the probability that a farmer will not adopt. Hence, the dependent variable is binary and its value is 1 for a farmer who adopted improved maize variety and 0 for a farmer who did not adopt. As Z_i range from $-\infty$ to $+\infty$, P_i range from 0 to 1, and P_i is non-linearly related to Z_i. Z_i is a linear function of the explanatory/independent variables X_i defined as follows:

X_1 is age, X_2 is sex, X_3 is household size, X_4 is experience, X_5 is off-farm income, X_6 is education, X_7 is extension, X_8 is credit, X_9 is farm size, X_{10} is market, X_{11} is membership, β_0 is constant, $\beta_1 - \beta_{11}$ is logistic regression coefficients, and e is error term.

Objective 2 was analyzed using the ordinary least square (OLS) model. The model is specified as:

$$Y_i = \alpha_0 + \alpha_1 X_1 + \cdots + \alpha_7 X_7 + e \tag{3}$$

where Y_i is household consumption expenditure, X_1 is adoption, X_2 is age, X_3 is education, X_4 is credit, X_5 is off-farm income, X_6 is household size, X_7 is landholding, α_0 is intercept, $\alpha_1 - \alpha_7$ is coefficients, and e is error term.

The summary statistics of all the variables used for analysis are presented in Table 1. Table 1 indicates that out of the 125 households sampled, 70% are male-headed households while the remaining 30% are female-headed households. The farmers are on average about 38 years of age which is an indication that they are mostly in their productive age bracket. They have mean household size of eight persons and have been farming for about 19 years on average. The mean level of education is 11 years showing that these farmers on average completed only junior secondary school. Only 20% had access to credit while 33% had access to extension services. The farm size dedicated to maize production is 4 hectares on average while total land holding is 9.47 hectares. The mean distance from house to the nearest market is about 7.9 km. Only 40% of the farmers are members of any farm group. The average consumption expenditure per capita per week is about ₦863.678 which is equivalent to US$5.60 at the prevailing exchange rate.

Table 1. Summary statistics of the variables used for analysis

Variable	Description	Mean	Standard deviation
Adoption	1 for a farmer who adopted improve maize variety; 0 otherwise	.400	.492
Age	Age of household head in years	38.104	10.793
Sex	1 if household head is male; 0 otherwise	.704	.458
Household size	Number of persons in the household	8.080	3.959
Experience	Number of years involved in farming	18.536	9.682
Off-farm income	1 for engagement in off-farm income generating activities; 0 otherwise	.672	.471
Education	Number of years spent in formal education	11.168	8.409
Extension	1 for farmers who were visited at least once during the last farming season; 0 otherwise	.328	.471
Credit	1 for farmers who had access to credit; 0 otherwise	.200	.402
Farm size	Farm size cultivated with maize in hectares	3.960	3.819
Market	Distance from house to nearest market in km	7.920	8.826
Membership	1 for membership of a farmer group; 0 otherwise	.400	.492
Landholding	Total land holding in hectares	9.468	6.461
Household consumption expenditure	Household consumption expenditure per capita in naira	863.678	984.069

3. Results and discussion

3.1. Factors influencing adoption of new maize varieties

Logit model was used in estimating factors that influence adoption of new maize variety. The result for the specification in Equation 2 is presented in Table 2 column 2 named Model 1. The log likelihood function is statistically significant at 10% level. This implies that the variables (farmers socioeconomic characteristics, institutional, and other policy variables) included in the Logit model are jointly significant in determining farmers decision to adopt improved maize varieties. However, only four out of the eleven variables are individually statistically significant. These are age, household size, off-farm income, and education.

The coefficient of age was found to be significant at 10% level and positively related to the adoption of improved maize variety in the study area. This implies that older respondents adopted new varieties more than young farmers. This study is contrary to the a priori as younger people have been found to adopt innovation more easily than the older ones. The coefficient of household size was found to be significant at 5% level and negatively related to the adoption of improved maize variety in the study area. This is not in line with the finding of (Bamire, Fabiyi, & Manyong, 2002) which says family size has been recognized to play a vital role in the adoption of any particular technology or farm practice. This could be due to the level of education of the household heads and his members. Moreover, large household size might imply more cash constrain as the need to meet the family daily requirements increase with large family size, thus leaving the household with little cash to purchase production inputs and new technologies.

The coefficient of off-farm income was found to be significant at 10% level and positively related to the adoption of improved maize variety in the study area. This result implies that the farmers who engaged in off-farm activities had more money available for purchase of improved maize

Table 2. Logit regression of factors influencing adoption of improve maize variety

	Model 1		Model 2		Model 3		Model 4	
Variables	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Age	.055*	.029	−.054**	.028	−.053*	.028	−.051*	.027
Sex	−.300	.444	−.228	.441	−.221	.441	−.217	.440
Household size	−.145**	.070	−.151**	.069	−.146**	.068	−.145**	.068
Experience	.009	.022	–	–	–	–	–	–
Off-farm income	.872*	.429	.809*	.423	.781*	.417	.763	.414
Education	.052*	.028	.054*	.028	.053*	.028	−.054**	.028
Extension	.010	.439	.189	.451	–	–	–	–
Credit	.179	.463	.475	.536	.455	.533	.418	.524
Farm size	.031	.064	.029	.064	.029	.063	.027	.062
Market	−.013	.025	−.018	.025	−.015	.024	−.015	.024
Membership	.108	.441	.160	.436	.172	.436	–	–
Constant	1.840*	.991	1.611*	.988	1.621*	.983	1.594*	.981
Log likelihood	−77.360*		−77.350*		−77.438*		−77.516*	

*Statistical significance at 10% level.

**Statistical significance at 5% level.

varieties which could lead to increased productivity. The coefficient of education was found to be significant at 10% level and positively related to the adoption of improved maize variety in the study area. This agrees with earlier studies such as Feder, Just, and Zilberman (1985) and Awe (1999) who found that literacy level positively influenced the intensity of use of fertilizer technology in Berkeley, the USA, and southwestern Nigeria, respectively. In the Logit analysis, access to extension agent, credit, farm size, experience, and membership were found to be insignificant at any of the conventional levels of significance but positively related to adoption of improved maize variety while sex and distance to the market were also found to be insignificant but negatively related to adoption of improved variety of maize.

A robustness check was performed to ensure that the results are not sensitive to particular specifications. A robustness check can be done for the Logistic regression using various means such as using different estimators, different weight functions, different standard errors, inclusion or exclusion of the constant term, and omission of some regressors (Bianco & Martínez, 2009; Cramer, 2007). Here, the sensitivity of the results obtained is checked by estimating the Logit model with omission of some of the variables. It is often assumed that the omission of a relevant orthogonal regressor leads to increased unobserved heterogeneity, and this depresses the β coefficients of the remaining regressors toward zero. For the Probit model, Wooldridge (2002) has shown that this bias does not carry over to the effect of these regressors on the outcome. Cramer (2007) find by simulations that this also holds for the Logit model, even when omitting a variable leads to severe misspecification of the disturbance. To see how the parameters and the impacts may be affected with variable omissions, three other specifications were estimated. In Model 2, farming experience is removed from the Model 1 which serves here as the benchmark model. The reason for the omission is based on the fact that age can be used as a proxy for experience, implying that one can use age instead of experience. In Model 3, the least significant variable, extension was omitted in addition to experience. In Model 4, the next least significant variable, membership of a farm group was omitted in addition to experience and extension. Overall, there seem to be slight changes in the coefficients but no changes in the direction and significance of the impacts of the variables as only those

variables (age, household size, education, and off-farm income) which were significant in the benchmark model remained significant in all the other models except in Model 4 where off-farm income was not significant.

3.2. The welfare effect of improved maize variety

To estimate the effect of adoption of improved maize variety on household welfare, the OLS model was employed. The linear, the double-log, and the semi-log functional forms were tried. The various results are presented in Tables 3–5. The double log was selected as the best model based on R^2 value, *F*-value, sign, and statistical significance of the variables. Hence, the discussions that follow is based on the double-log specification as presented in Table 5. This implies that all variables except dummy variables were used in log form. Also, the coefficients could be interpreted as elasticities. The model fit does not seem quite good as the R^2 is .28. This implies that only 28% of the variation in welfare is explained by the variables included in the model while the remaining 62%

Table 3. OLS regression of welfare effect of improved maize variety based on linear specification

Variables	Coefficient	Standard error	*t*-Statistic
Adoption	358.836*	186.382	1.930
Age	10.307	11.673	.880
Education	13.891	11.754	1.180
Credit	136.505	226.428	.600
Off-farm income	27.981	194.525	.140
Household size	73.319**	30.802	2.380
Landholding	5.453	14.285	.380
Constant	721.558*	440.708	1.640
R^2	.082		
Adjusted R^2	.027		
F	1.490		

*Statistical significance at 10% level.
**Statistical significance at 5% level.

Table 4. OLS regression of welfare effect of improved maize variety based on semi-log specification

Variables	Coefficient	Standard error	*t*-Statistic
Adoption	.376***	.141	2.67
Age	.011	.009	1.250
Education	.009	.009	1.040
Credit	.006	.147	.040
Off-farm income	.176	.147	−1.200
Household size	.075***	.023	−3.200
Landholding	.003	.011	−.300
Constant	6.506***	.333	19.530
R^2	.157		
Adjusted R^2	.107		
F	3.110***		

***Statistical significance at 1% level.

Table 5. OLS regression of welfare effect of improved maize variety based on double-log specification

Variables	Coefficient	Standard error	*t*-Statistic
Adoption	.409***	.141	2.890
Age	.393	.337	1.170
Education	.031*	.019	1.650
Credit	.068	.148	.460
Off-farm income	.184	.150	1.230
Household size	.534***	.176	3.030
Landholding	.160*	.098	1.640
Constant	6.588***	1.040	6.330
Adjusted R^2	.238		
F	6.540***		

*Statistical significance at 10% level.

***Statistical significance at 1% level.

are explained by other factors not included in the model. The constant parameter is significant at 1% level which implies that consumption expenditure cannot be zero even if all the variables included in the model are zero. However, with the *F*-statistics being significant at 1%, it means that all the variables included in the model are jointly significant in influencing household welfare.

Looking at the variables only four are statistically significant. These are adoption, education, household size, and landholding. Education and landholding of farmers were found to be significant at 10% level and positively related to household welfare while adoption and household size were found to be significant at 1% level and positively related to household welfare. Therefore, the second null hypothesis stated in this study is rejected, that is, the hypothesis that adoption of improved maize variety has no significant effect on household welfare is rejected. The economic interpretations of these significant variables are further explained in detail.

Adoption of improved maize varieties by farmers was found to be significant at 1% level and positively related to household welfare of the farmers. This result shows that farmers who adopted improved maize varieties were more financially buoyant than those who did not. This is intuitive because adoption of improved maize varieties is expected to lead to increased production and productivity and consequently improving farm incomes and hence household welfare. The result also shows that the level of education of the respondents was a very important factor at 10% significant level as it positively influenced the welfare of farmers in the study area. This implies that literacy improves the welfare of farmers. This is because educated farmers are more prone to off-farm jobs that generate off-farm income; they are more knowledgeable in loan processing.

The result reveals a positive and significant at (1%) relationship between household size and the household welfare. This implies that increase in family size positively influences the welfare of the household through increases in the availability of labor. The bigger the family size, the more economically stable the family would be. The result shows that Land holding size is significant at 10% level and positively related to the welfare of the household. This implies that, farmers with large land holding size will surely generate more income through large-scale production of improved maize, through allocation of land to different crops to be planted in one season, through sale of part of the land since it is large enough and finally, since it is an asset, it could be used as collateral when seeking for loan thereby improving the farmers welfare and standard of living relative to the farmers small land holding.

Table 6. Average effects of adoption of improved maize variety on household welfare

Outcome variable	No. treated	No. control	ATT	Standard error	*t*-Statistic
Household consumption expenditure per capita	50	72	.403	.177	2.279

Note: ATT denotes average treatment effect of the treated.

Adoption is not randomly distributed to the two groups of the households (as adopters and non-adopters), but rather the household itself deciding to adopt given the information it has (Amare et al., 2012). Therefore, adopters and non-adopters may be systematically different. Therefore, further robustness check was performed to ensure the potential endogeniety and/or self-selectivity bias of adoption decisions is accounted for by implementing a PSM approach. Since the Logit result from the PSM technique produced exactly similar result as the benchmark Logit model in Table 2, we present here only the result for the Average Treatment Effect on the Treated (ATT) that measures the average difference between consumption expenditure per capita of households who adopted improved maize variety and those who did not adopt as well as the corresponding standard error and *t*-statistic (Table 6). It is observed that adoption of improved variety has positive effect on household welfare and this is significant at 5% level. This result is similar to that from the OLS model with exception that while the PSM shows the effect is significant at 5%, OLS shows it is significant at 1%.

4. Conclusion

This study was carried out to determine the welfare effects of improved maize technology in Buruku Local Government Area of Benue State, Nigeria. The study also examined the determinants of the adoption of improved maize technology. Structured questionnaires were used in collecting the primary data for the study. A multi-stage random technique was used in selecting 125 farm households for the study. The Logit and OLS models were used in analyzing the data. The OLS results show that adoption of improved maize varieties is positively and significantly related to household welfare and thus contributed to reducing poverty among farm households in the area. Other variables found to be statistically significant in explaining household welfare are, education, household size, and landholding. Results from the Logit model indicate that age, household size, off-farm income, and education were found to be significant in influencing farmers' adoption decisions. A robustness check was performed to ensure that the results are not sensitive to particular specifications. This was done by estimating the Logit model with omission of some of the variables. Overall, there seem to be slight changes in the coefficients but no changes in the direction and significance of the impacts of the variables. Moreover, to account for self-selectivity of adoption, a PSM approach was employed. This however did not change the findings based on previous estimations; the only difference being that while the OLS model shows that adoption is significant at 1% in influencing household welfare; the ATT estimation of the PSM shows it is significant at 5%. These results suggest that policies that will promote the development and dissemination of appropriate agricultural technologies to farmers can facilitate the achievement of the millennium development goal of reducing poverty and hunger in the developing countries such as Nigeria. Particularly, the need to promote non-farm income opportunities, improvement of the quality of farm household members, and revitalization of the education policy to make education readily available to farming communities cannot be overstressed.

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