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Table of Contents: Volume 6 Number 4 April 2014

ARTICLES

Research Articles

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Full length Research Paper

Understanding situational incompatibility of payment for the delivery of public extension services

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Persistent financial problems confront public extension organizations world-wide. Governments have embarked on funding arrangements, including commercializing the delivery of extension services to producers to ensure financial sustainability. These funding methods are innovative in the sense that they have not been used previously. They have to be accepted eventually by producers. The situational incompatibility aspects represent the barriers en route to the adoption of such innovations. This study therefore attempts to identify the perceived problem/barriers, commonly called independent variables associated with the adoption of innovations, such as the payment for the delivery of public extension visits. Further assessment is made of the important independent variables that contribute the most to the variance in the adoption of payment for the delivery of public extension visits. A non-probability survey of 97 medium and small-scale commercial crop farmers was conducted between September and October 2010 in three districts of the Free State Province. Findings indicate that farming orientation, group membership, desired number of visits and perceived credibility of the public extension service made the most contribution to explain the variation in the adoption of the payment for the delivery of public extension visits. Credibility of information source and desired number of visits made the single most important contributions. These findings have positive implications for funding extension service delivery.

Key words: Situational incompatibility, medium and small-scale commercial farmers, payment for delivery of public extension, independent variables.

INTRODUCTION

Financial constraints, especially, inadequate operating funds beset public extension services world-wide including South Africa (Gebremedhin et al., 2006; Umhlaba Rural Services, 2007). This problem seems to be persistent, affecting both developed and developing countries (Fei and Hiroyuki, 2000; World Bank, 1994). This had led to ineffective extension work among others (Rivera, 1991). Public extension organizations globally have since the 1980's been adopting reform measures to ensure financial sustainability of their operations (Qamar, 2002; Rivera and Alex, 2004c). The operational financial problems facing public extension worldwide have spurred on calls for users of public extension services to contribute towards the recurrent cost of extension if

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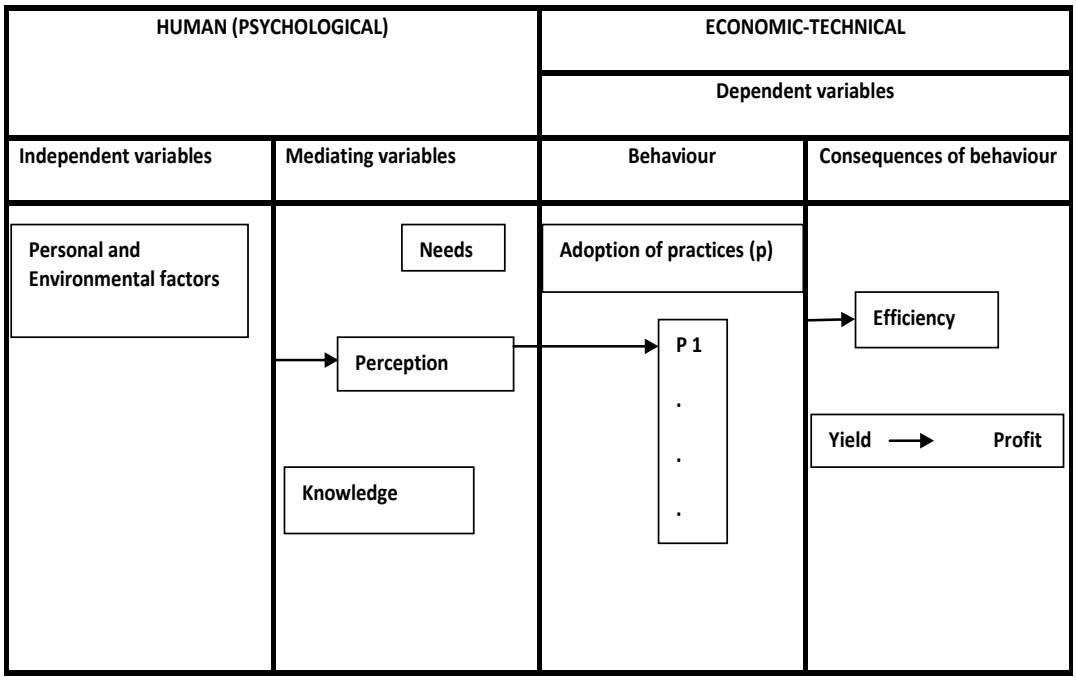

Figure 1. Relationship between behavior- determining variables, behavior and consequences of behavior (Düvel, 1991).

financial sustainability and accountability are to be achieved and to make public extension effective (Neuchâtel Group, 2002; Holloway and Ehui, 2001 cited in Anderson, 2008). There are indications that extension cost recovery initiatives are spreading around the world (World Bank, 2006 cited in Anderson, 2008). Among the extension activities that have been commercialized in some developed and developing countries are dissemination of information and direct contact with growers in the field (Dinar, 1996). Direct contacts such as farm visits, however, take up a lot of extension workers' time and financial resources to accomplish (Dinar, 1996; Wilson and Gallup, 1955). Among the issues that make for ineffectiveness of the public extension system in South Africa is few number of visits by public extension officers to farmers (Jacobs, 2003). Some examples of payment for extension farm visits exist in Israel (Dinar, 1996), Ethiopia (Holloway and Ehui, 2001) and India (Shekara, 2001).

Insights gained from the literature review, however, show that empirical research regarding farmer payment for the delivery of public extension visits is non-existent in South Africa. This notwithstanding, some papers have been published on the broader issue of commercialization/privatization of extension services in this country (Botha and Treunicht, 1997; Eweg and Owens, 2004). It therefore, stands to reason that a current and pressing need exists for investigations into and analytical studies of the important factors that influence farmers to contribute towards/accept payment for the delivery of public extension visits.

Theoretical framework

The critical and decisive issue in the search for the most appropriate mode of financing public extension delivery is that it will have to be adopted by the farmer producers. This brings to the fore the crucial role of the human being, and the challenge to understand and influence his/her adoption behaviour. The adoption of an innovation perceived to have a few positive aspects is made even more difficult if it is fraught with a number of negative dimensions. The latter consists of disadvantages pertaining to the innovation as well as the barriers en route to the goal. The disadvantages relate more to the innovation as such and can be changed to positive forces; the situational incompatibility aspects however, represent the barriers, commonly called independent variables, associated with adoption of innovations and are potentially negative (Düvel, 1991). Düvel (1991) represented the behaviour determinants and their influence relationship in the context of behaviour change and the results of behaviour change as shown in Figure 1.

Aims and objectives

This study, therefore, was motivated by the need to investigate the possibility of user contributions for the delivery of public extension visits as a way of generating more operational funds to finance such extension visits. This is particularly important because nationally, medium and small-scale commercial farmers, the target

Table 1. Distribution of respondents according to farming orientation and payment for the delivery of public extension visits (N = 97).

Payment decision	Farming orientation					
	Part –time		Full –time		Total	
	n	%	n	%	N	%
No	13	46.4	17	24.6	30	30.9
Yes	15	53.6	52	74.5	67	69.1
Total	28	100.0	69	100.0	97	100.0

$\chi^2 = 4.427$; df = 1; p = 0.035; Significant = 0.05.

population of this study, use 21 to 30% of public extension time (Düvel, 2002) and receive farm management information/service from public extension via farm visits. The objective of this paper was to identify the important independent variables that influence medium and small-scale commercial crop farmers' acceptance to pay for the delivery of public extension visits. The hypothesis of the study was: An incompatibility of payment for the delivery of public extension visits with the situation of the farmer has influence on the acceptance to pay for the delivery of public extension visits. The specific hypotheses are:

1. Farming orientation may have a positive influence on the payment for the delivery of public extension visits.
2. Group membership has a positive influence on the payment for the delivery of public extension visits.
3. Percentage earnings from farming have a positive influence on the payment for the delivery of public extension visits.
4. Desired number of extension visits has a positive influence on the payment for the delivery of extension visits.
5. The credibility of public extension service provider has a positive influence on the payment for the delivery of public extension visits.
6. The effect of drought on gross farm sales has a positive influence on the payment for the delivery of public extension visits.
7. Farming experience may have a positive influence on the payment for the delivery of public extension visits.
8. Mentorship has a positive influence on the payment for the delivery of public extension visits.
9. The type of farming enterprise has a positive influence on the payment for the delivery of public extension visits.

RESEARCH METHODS

This paper is based on a survey of medium and small-scale -scale commercial crop farmers[1] in three of the five districts of the Free State Province, South Africa. Convenience and purposive, non-probability sampling techniques were used to survey farmer respondents because of a lack of reliable sampling frame. A semi-structured, self-administered, pre-tested questionnaire was used to collect information from 97 farmer respondents between 1 September and 7 October 2010. After a critical examination of the literature on the adoption of innovations, nine independent variables relevant to the adoption of payment for the delivery of farm visits were identified. These variables were chosen to ensure content validity of the measuring instrument (Cooper and Schindler, 2001). The questionnaire, therefore, asked respondents amongst other issues to indicate information on their farming orientations, percentage earnings from farming, group memberships, desired number of public extension visits, effect of drought on their gross farm incomes, farming enterprises, farming experiences, farming with the support of mentors, credibility of public extension provider. Effort was expended to improve the reliability of the measuring instrument by eliminating or reducing subject bias, observer bias and observer error Saunders et al. (2000).

Following Stockburger (1998), in which categorical variables with two levels may be directly entered as predictors or predicted variables in a multiple regression model, a multiple regression model was specified to study the relationship between the study variables and payment for the delivery of public extension visits. The prediction of Y is accomplished by the following equation:

$$\grave{Y}_{\,i} = b_0 + b_1 X_{\,i} + \varepsilon_1 \; (1 = 1, 2, 3, ...n)$$

Where $\grave{Y}$ is the predicted value of the dependent variable, namely payment for the delivery of public extension visits, the *b* values are the regression weights or the coefficients of the predictor variables, the X's represent the various predictor variables (mediating variables), ε_1 is the error term and n is the number of observations. The data were analysed using the Statistical Package for the Social Sciences (SPSS). The data were analysed by means of descriptive statistics and two key inferential statistical procedures, namely the Chi Square (X^2) tests of independence and multiple linear regression analysis which were used to test whether any observed differences were statistically significant.

RESULTS AND DISCUSSION

The results of the nine independent variables and their influence relationship with the payment for the delivery of public extension visits investigated in this study are presented as follows:

Farming orientation

Table 1 shows the results of the investigation of the

[1]The small/medium-scale farmer definition adopted for this study after careful study of the literature was "farmers who produce mainly for the market and LRAD beneficiaries who may have own consumption and the market in view as the ultimate purpose of production".

Table 2. Distribution of respondents and their decision to pay for the delivery of public extension visits according to percentage earnings from farming (N = 97).

Payment decision	Percentage earnings from farming (% of total income)									
	0 to 24		25 to 49		50 to 74		75 to 100		Total	
	n	%	n	%	n	%	n	%	N	%
No	5	35.7	10	58.8	4	19.0	11	24.4	30	30.9
Yes	9	64.3	7	41.2	17	81.0	34	75.6	67	69.1
Total	14	100.0	17	100.0	21	100.0	45	100.0	97	100.0

χ^2 = 8.616, df = 3, p = 0.035; Significant = 0.05.

Table 3. Distribution of respondents and their decision to pay for the delivery of public extension visits according to their group membership (N = 97).

Decision to pay	Group membership					
	No		Yes		Total	
	n	%	n	%	N	%
No	14	45.2	16	24.2	30	39.9
Yes	17	54.8	50	75.8	67	69.1
Total	31	100.0	66	100.0	97	100.0

χ^2 = 4.321, df = 1, p = 0.038; Significant = 0.05.

influence relationship between farming orientation (full-time or part-time farming) and the adoption of payment for the delivery of public extension visits. The result was positive influence (p = 0.035). The study hypothesis that the farmer's situation as a full-time or part-time farmer influenced payment was thus supported. In this case, full time farmers were more inclined than part time farmers to pay for extension visits. The available literature on the influence of farming orientation on adoption of farm innovations is mixed. The expected difference between full-time and part-time farmers with respect to willingness to pay is ambiguous and therefore, seemed to be situation specific. Sulaiman and Sadamate (2000) for example, found non-significant results in two of their research sites while reporting a significant result in a third area of their study. Kenkel and Norris (1995) on the other hand found that farming orientation significantly influenced the adoption of raw weather data but a non-significant result on value-added data.

Percentage earnings from farming

The investigation of the effect of the percentage earnings per year from farming was found to be positively related to payment for the delivery of public extension visits (Table 2) as indicated by a significant Chi-square test for independence at 5% level (p = 0.035). The study hypothesis was thus supported. The general picture was that as the percentage earnings per year derived from farming increased, the percentage of respondents who showed a tendency to accept to pay for the delivery of public extension visits also increased, although, the increase was not linear. This was particularly evident when the income from agriculture exceeded 50%. The positive significant influence of the percentage earnings per year from farming on payment for the delivery of public extension visits found in this study was similar to the finding reported by Sulaiman and Sadamate (2000) who found this variable to significantly influence respondents' willingness to pay for agricultural-related information in two of the three survey areas. Yapa and Ariyawardana (2005) also mentioned similar findings with their small-scale tea growers in Sri Lanka.

Group membership

Table 3 shows there was significant positive relationship between group membership among respondents in this survey and payment for the delivery of public extension visits (p = 0.038). This finding supported the study hypothesis. Similar findings were reported by Ajayi (2006) and Gautam (2000). Habtemariam (2004) also indicated a tendency among his efficient respondents to be slightly more organizationally involved. Daramola (1989) however, did not find co-operative membership to significantly influence the probability of fertilizer adoption decisions in his sample and in fact, its influence was negative. A possible reason could be culturally-related where the people tended to be individualistic because of

Table 4. Distribution of respondents and their decision to pay for the delivery of public extension according to their desired number of extension visits (N = 97).

Decision to pay	Desired number of visits per month											
	1		2		3		4		5		Total	
	n	%	n	%	n	%	n	%	n	%	N	%
No	12	66.7	1	6.7	2	10.5	15	30.0	0	0.0	30	30.9
Yes	6	33.9	5	3.3	17	89.5	35	70.0	4	100.0	67	69.1
Total	18	100.0	6	100.0	19	100.0	50	100.0	4	100.0	97	100.0

X^2 = 16.847, df = 4, p = 0.002.

Table 5. Distribution of respondents' views on the effect of drought on their gross farm income according to their desire to pay for public extension (N = 77).

Decision to pay	Respondents' views on the effect of drought on the gross farm income					
	Very little to not affected		Much to very much affected		Total	
	n	%	n	%	N	%
No	6	27.3	22	40.0	28	36.8
Yes	16	72.7	33	60.0	49	63.6
Total	22	100.0	55	100.0	77	100.0

X^2 = 1.100, df = 1, p = 0.432; Missing = 20.

lack of trust of other people in group settings. Another possible explanation why people might not join groups like farmer co-operative as in his sample might be due to past disappointments with such groups. These findings clearly suggested that, although group membership is a great enhancer of the adult learning and adoption process, adoption is not guaranteed by group membership.

Desired number of visits

Respondents' desired number of visits was found to have a significant positive influence on the acceptance to pay for the delivery of public extension visits (Table 4) (p = 0.002). The study hypothesis was thus supported. A significant finding was that, of the farmers who wished to receive between 2 and 4 visits per month, with a mean of 3.16 visits per month (SD = 1.213), most of them (89.5%) wanted to pay. The mean number of visits reported in this study was close to the designated visits of one every two weeks (or 2 visits per month) in the Kenya extension project (Gautam, 2000) and similar to the 2 visits per month requested by livestock farmers in Turkey (Budak et al., 2010). The desired number of visits by respondents in this survey is much higher by any standards than that reported by Gautam (2000) who indicated that more than two-thirds of the respondents in his survey desired to receive one visit every three months while 50% of contact farmers desired to meet the extension officer no more than once every three months. These differences in reported number of visits in this study and others might be due to different amounts of resources available to the particular extension organizations. Farmers would not want to meet their extension worker often if they perceived that the encounter would not add value to their work. In fact, they saw such encounters as a waste of their precious time. This had been observed by Gebremedhin et al. (2006) in Ethiopia, where farmers claimed they knew better than the development agents (DAs) in agricultural production, and all they needed the DA for was only input supply.

Effect of drought

The results (Table 5) showed that the effect of drought on producers' gross farm income did not seem to influence producers to pay for the delivery of public extension visits. This was indicated by chi-square results that lack significance (p = 0.432). The study hypothesis was, therefore, not supported. In a more direct question about respondents' views on the possible effect of the drought spells on their gross farm income if they paid for public extension, most respondents (80.8%) were hesitant, that is, had no idea whether it would be worth paying (Table 6). This seemed to suggest that respondents did not believe in the current competency level of the public extension service to rescue the situation under a paid public extension service. On a related question to assess

Table 6. Distribution of respondents' views on the effect of drought spells on gross farm income under a paid public extension service (N = 73).

Effect of drought spells on gross farm income under a paid public extension	Respondent	
	N	%
No idea	59	80.8
Not affected	7	9.6
Very little effect	7	9.6
Total	73	100.0

Missing = 24.

Table 7. Distribution of respondents' views on the effect of drought spells on gross farm income under a paid private extension (N = 73).

Effect of drought spells on gross farm income under a paid private extension	Respondents	
	N	%
No idea	40	54.8
Not affected	22	30.1
Very little effect	11	15.1
Total	73	100.0

Table 8. Distribution of respondents' farming enterprise according to their decision to pay for the delivery of public extension (N = 97).

Decision to pay	Farming enterprise									
	Vegetables		Sunflower		Maize		Lucerne		Total	
	n	%	n	%	n	%	n	%	N	%
No	20	38.5	1	9.1	9	30.0	0	0.0	30	30.9
Yes	32	61.5	10	90.9	21	70.0	4	100.0	67	69.1
Total	52	100.0	11	100.0	30	100.0	4	100.0	97	100.0

$X^2 = 5.640$, df = 3, p = 0.130.

the confidence of respondents in paid private extension service to mitigate the effect of drought on their gross farm income, only 54.8% did not seem to have confidence in a paid private extension service to reduce the gross income losses as a result of drought (Table 7). This implied that respondents had a little more confidence in a paid private extension service than a paid public extension service in this matter.

Farming enterprise

According to Table 8, farming enterprise did not influence the decision of producers in this survey to pay for the delivery of public extension visits (p = 0.130). The study hypothesis was thus not supported. A possible reason for this finding could be that so far as payment for the delivery of public extension visits was concerned, all the producers of the crops in the survey had need for more farm management information/advice/service and therefore, for more contacts with the public extension agent. They were prepared to pay for such visits. For this reason, the types of crops planted did not significantly discriminate between those who would and those who would not. Kenkel and Norris (1995) found similar results and stated that for the raw data/value-added model, the production of peanuts, cotton, or alfalfa did not significantly impact willingness to pay.

Farming experience

This variable was investigated in this study and the results are presented in Table 9. The majority of farmers (74.2%) in this survey had between 1 to 5 years farming experience with a median experience of 1 year. According to the results, farming experience did not influence the decision of producers in this survey to adopt the payment for the delivery of public extension visits (p = 0.985). The study hypothesis was therefore, not

Table 9. Distribution of respondents' farming experience and their decision to pay for the delivery of public extension visits (N = 97).

Decision to pay	Farming experience category							
	1 to 5		6 to 10		11 to 15		Total	
	n	%	n	%	n	%	N	%
No	22	30.6	5	1.3	3	33.3	30	30.9
Yes	50	69.4	11	68.8	6	66.7	67	69.1
Total	72	100.0	16	100.0	9	100.0	97	100.0

$X^2 = 0.030$, df = 2, p = 0.985.

Table 10. Distribution of respondents involved in mentorship and their decision to pay for the delivery of public extension visits (N = 97).

Decision to pay	Respondents' involvement in mentorship					
	Not involved		Involved		Total	
	n	%	n	%	N	%
No	29	33.0	1	11.1	30	30.9
Yes	59	67.0	8	88.9	67	69.1
Total	88	00.0	9	100.0	97	100.0

$X^2 = 1.824$, df = 1, p = 0.177.

Table 11. Distribution of respondents' assessment of the credibility of the public extension service and their decision to pay for the delivery of public extension visits (N = 97).

Decision to pay	Respondents per overall credibility category					
	Less credible		More credible		Total	
	n	%	n	%	N	%
No	20	45.5	10	18.9	30	30.9
Yes	24	54.5	43	81.1	67	69.1
Total	44	100.0	53	100.0	97	00.0

$X^2 = 7.955$, df = 1, p = 0.005.

supported. This finding was similar to other past studies (Chukwuone and Agwu, 2005; Kenkel and Norris, 1995).

Farming with the support of a mentor

The results (Table 10) suggest that mentorship did not influence the decision of respondents in this survey to pay for the delivery of public extension visits (p = 0.177). The study hypothesis was, thus not supported. The Master Mentorship Programme was launched within the South African agricultural system by the Department of Agriculture in 2005 and was piloted in 2006 (Department of Agriculture, Forestry and Fisheries, 2009). In 2008, only the Milk Producers' Organization (MPO) conducted a mentorship programme in the Free State where this study was conducted (Department of Agriculture, Forestry and Fisheries, 2009). The data (Table 10) show that only 9.3% of the total number of respondents in the survey reported farming with a mentor. This indicated that the mentorship programme had not caught on well in this province; this could be a possible reason for the lack of influence of this variable on the adoption of payment for the delivery of public extension. This notwithstanding, there was an indication in the results that a large proportion of respondents farming with a mentor (88.9%) indicated a desire to pay for the delivery of public extension.

Credibility of public extension service provider

There was evidence (Table 11) that respondents' opinions as revealed in their assessment of the credibility of the public extension service provider relative to other sources of farm management service/information that credibility had a positive effect on the acceptance to pay

Table 12. Multiple regression estimates of the effects of the independent variables on the payment for the delivery of public extension visits.

Variable	Beta	T	P
Farming orientation	0.127	1.006	0.001*
Percentage farm earnings	0.173	1.488	0.142
Farming enterprise	0.236	1.862	0.067
Farming experience	0.203	-1.739	0.087
Credibility	0.549	6.429	0.000*
Drought effect on gross farm income under paid public extension	0.233	1.740	0.086
Desired number of visits	0.290	3.183	0.002*
Mentor	-0.020	-.231	0.818
Group membership	0.149	1.724	0.009*
Constant	-	-5.266	0.000

R^2 = 0.588; Significant at 0.01*

for the delivery of public extension visits (p = 0.005). Ajayi (2006) made a similar finding in Nigeria based on the assessment of the extent to which respondents were visited and trained on relevant agricultural production-related activities. What should be of concern to policy makers though is the fact that about 45% of respondents did not find the public extension credible. About 54% of this number however, would still like to pay for the delivery of public extension; perhaps this is because it was the only source they could afford compared with private extension. Policy makers should think seriously about improving the competency of field level extension practitioners to be able to service their clientele better.

Contributions of independent variables to variation in the adoption of payment for the delivery of public extension visits

To assess more accurately the contribution of the independent variables on the adoption of the payment for the delivery of public extension visits, a multiple regression analysis was employed. All nine independent variables did not show multi-collinearity and as a result were entered into the regression analysis. The results are shown in Table 12. The analysis shows that all variables except mentor and farming experience positively correlated with the dependent variable. However, only farming orientation, credibility of the extension service/agent, desired number of visits and group membership made a significant contribution to the variance in adoption of payment for the delivery of public extension visits. Together, these four variables explained 58.8% of the variation in the adoption of the payment delivery of public extension visits. The model was significant (at 5% level) (F = 10.477, p = 0.004). The credibility of the extension agent/service made the largest contribution (0.549) to the payment adoption variance. The next biggest contributor was desired number of visits (0.290). In terms of their contributions to the R^2, credibility and desired number of visits contributed 25.8 and 6.3%, respectively.

SUMMARY OF CONTRIBUTIONS AND CONCLUSIONS

Regarding the objective of the study, findings indicate that farming orientation, percentage earnings from farming, group membership, desired number of visits and the perceived credibility of the public extension service were the important variables that positively influence respondents' acceptance to contribute towards the delivery of public extension visits. Of these variables, desired number of visits and perceived credibility of the public extension service made the most single, independent contributions towards the adoption variance. These findings imply that it was possible to secure financial contributions from users of the public extension service to finance more extension visits. This would contribute towards the financial sustainability of the public extension service and make it possible for extension agents to visit farmers optimally. Another implication of these findings was that any extension programme to secure the acceptance of producers to contribute towards the cost of public extension visits should pay particular attention to these 4 variables that had been identified in this study. The findings in this study could help shape policy towards farmer contributions to the cost of delivery of visits to farmers. Among the issues, policy makers should pay special attention to and improve is its credibility as perceived by producers if they hope to get more and more producers to buy into the idea of contributions for the delivery of extension visits. Furthermore, the public extension service should try and provide the number of visits (2 to 4 per month) producers' desired from the public extension agent to motivate producers to contribute towards the cost of extension visits.

The study was based on non-probability sampling and this makes it inappropriate to generalize the results to the wider medium and small-scale commercial crop farmers in South Africa. A replication of the study by means of probability sampling methods would validate the veracity of the findings in the larger population of medium and small-scale commercial crop farmers in the country.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Ajayi AO (2006). 'An Assessment of Farmers' willingness to pay for extension services using the Contingent Valuation Method (CVM): The case of Oyo State, Nigeria', J. Agric. Educ. Ext.12(2):97-108.

Anderson JR (2008). Agricultural Advisory Services, Background paper for World Development Report 2008, Agriculture for Development, Washington DC: World Bank.

Botha CAJ, Treurnicht S (1997). Converting South African State Extension Services: A sustainable development framework, S. Afr. J. Agric. Ext. 26(3):1-52.

Budak DB, Budak F, Kaçira O (2010). Livestock producers' needs and willingness to pay for extension services in Aduna Province of Turkey. Afr. J. Agric. Res. (11):1181-1190.

Chukwuone NA, Agwu AE (2005). 'Financing agricultural technology delivery in Nigeria: Would farmers be willing to pay?' J. Ext. Sys. 21(2):69-85.

Cooper DR, Schindler PS (2001). *Business Research Methods* (7thed.). Mcgraw-Hill, Boston.

Daramola B (1989).The Study of Socio-economic Factors influencing Fertilizer Adoption Decisions in Nigeria: A Survey of Oyo State Farmers. Fertil. Res. 20:143-151.

Department of Agriculture, Forestry and Fisheries (2009). Annual Report on the Implementation of the Commodity-Based Master Mentorship Programme, Education, Training and Extension Services, Pretoria. P. 246.

Dinar A (1996). Extension Commercialization: How much to charge for extension services. Am. J. Agric. Econ. 78(1):1-12.

Düvel GH (2002). Towards an appropriate extension approach for South Africa (Final Report), South African Institute for Agricultural Extension, University of Pretoria.

Düvel GH (1991). Towards a model for the promotion of complex innovations through programmed extension. S. Afr. J. Agric. Ext. 20:70-86.

Eweg MJ, Owens ME (2004). South Africa: Public-Private Partnership for Extension Delivery. In W. Rivera and G. Alex (Eds.), Privatization of Extension Systems. Vol. 2Case Studies of International Initiatives. Agricultural and Rural Development Discussion paper 9, Washington DC:International Bank for Reconstruction and the World Bank.

Fei X, Hiroyuki T (2000). Fee-charging extension in China: Implications and Function, J. Ext. Sys. 16:58-67.

Gautam M (2000). Agricultural Extension: The Kenya Experience: An Impact Evaluation. World Bank, Washington DC.

Gebremedhin B, Hoekstra D, Tegegne A (2006).Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator International Livestock Research Institute (ILRI), Addis Ababa.

Habtemariam AG (2004). The Comparative Influence of Intervening Variables in the Adoption Behaviour of Maize and Dairy Farmers in Shashemene and Debrezeith,Ethiopia, PhD thesis, University of Pretoria, South Africa.

Holloway GJ, Ehui SK (2001). Demand, supply and willingness-to-pay for extension services in an emerging market setting. Am. J. Agric. Econ. 83:764-68.

Jacobs P (2003). Evaluating Land and Agrarian Reform in South Africa. An Occasional Paper Series 4, Cape Town:Program for Land and Agrarian Studies, University of Western Cape Cape Town.

Kenkel PL, Norris PE (1995). Agricultural Producers' Willingness to pay for Real- Time Meso-scale Weather Information. J. Agric. Res. Econ. 20(2):356-372.

Neuchâtel Group (2002). Common framework on financing agricultural and rural extension. Switzerland:Neuchâtel Group.

Qamar MK (2002). Global trends in agricultural extension: challenges facing Asia and the Pacific Region' paper presented at the FAO Regional Expert Consultation on Agricultural Extension, Research-Extension – Farmer Interface and Technology Transfer, held in Bangkok; 16-10 July, 2002.

Rivera WM, Alex G (Eds.) (2004c). National Strategy and Reform Process, Volume 5: Case studies of International Initiatives, Washington DC:International Bank for Reconstruction and Development/ World Bank.

Rivera WM (1991). Worldwide Policy Trends in Agricultural Extension, Part 1. J. Technol. Transfer. 16(1):13-18.

Saunders M, Philip L, Thornhill A (2000). Research Methods for Business Students (2nded.). Harlow:Prentice-Hall.

Shekara C (2001). Private Extension: The India Way', in P.C. Hekara (ed.), Private Extension: Indian Experiences, National Institute of Agricultural Extension Management (MANAGE), Hyderabad.

Stockburger DW (1998). Multivariate Statistics: Concepts, Models and Applications.http://www.psyhstat.missouristate.edu/multibook/mlt00.htm (Accessed 10 May 2011).

Sulaiman R, Sadamate VV (2000). Privatizing agricultural extension in India'. Policy Paper 10 New Delhi, National Centre for Agricultural Economics and Policy Research (NCAP). P. 95.

Umhlaba Rural Services (2007). National Review of the Comprehensive Agricultural Support Programme', www.participation.org.za/docs/CASPReviewMarch2007.pdf

Wilson M, Gallup G (1955). Extension Teaching Methods and factors that influence the adoption of agricultural and home economics practices. Circular United States Department of Agriculture, Washington DC. P. 459.

World Bank (1994). Agricultural Extension: Lessons from Completed projects, Operations and Evaluation Department Report World Bank, Washington DC. P. 1300.

Yapa KDA, Ariyawardana A (2005). Willingness to pay for a fee-based extension service by tea smallholders in Galle District. Sri Lankan J. Agric Econ. 7:69-84.

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Factors influencing rural household food insecurity: The case of Babile district, East Hararghe Zone, Ethiopia

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The paper examines the status and factors affecting food insecurity of rural household in Babile Ethiopia. A two-stage random sampling procedure was used to select 150 sample households from four kebeles. Both primary and secondary methods of data collection were used. Descriptive statistics and binary logit model were used as methods of data analysis. Binary logit model identified five out of ten variables included in the model as significant factors of rural household food insecurity. Size of cultivated land, educational status of the household head, annual farm income, use of improved variety, and insect and pest infestation problem were found significant factors influencing household food insecurity. The results of econometric analysis made it clear that these factors were the major determinants of household food insecurity in the study area.

Key words: Food, factors, binary logit model, rural households, Babile district, Ethiopia.

INTRODUCTION

Food security has become a crucial agendum all over the world because food is a very fundamental human right that transcends cultural, political background, and religious beliefs. In addition, the right to food is acknowledged in universal declaration of human rights as well as the international covenant on economic, social and cultural rights (ICESCR) which bring consequences to the state to ensure right to food which consists of obligation to respect, protect and fulfill (Hadiprayitno, 2010). Despite progress witnessed in reducing poverty in some parts of the world over the past couple of decades, dealing with persistent rural poverty has continued to constitute the economic development agenda of sub-Saharan Africa (IFAD, 2010). The region is the most vulnerable region to food security, in which about half of its population in food insecurity (Shapouri et al., 2009). The region is highly dependent on food import and food assistance.

Ethiopia remains one of the poorest countries in the world with human development index ranking 157 out of 169 countries reported (UNDP, 2010). With US$ 350, the country's per capita income is much lower than the sub-Saharan Africa average of US$ 1,077 in the year 2009 (World Bank, 2011). Despite the effort from the Ethiopian government and farmers' community, Ethiopia remains highly vulnerable to severe and chronic food insecurity in

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a large extent (CSAE, 2010).

According to Ministry of Agriculture (2012), Ethiopia has experienced high economic growth in recent years which was 11%, however despite this, significant poverty and chronic food insecurity remains in the country. It was estimated that about 38.7% of households were food insecure. Most of these food insecure households are subsistence farmers, and vulnerable to weather fluctuations. High population growth has also contributed to decline in farm sizes, and environmental degradation remains a problem. Dramatic variations in rainfall and repeated environmental shocks further contribute to poverty and food insecurity.

Based on the joint government and humanitarian partners' requirement document released, about 3.2 million people required food assistance in the first half of 2012. The highest needs were identified in Somali and Oromia regions where 34% of the total population of each region is estimated to be in need. The net food requirement is reported to be around 158,000 metric tons (USAID, 2012).

Consider the agro-ecological zone and farming system of Babile district, there are high spatial variations of food insecurity. This might leads to raise a fundamental question about how this variation occurred among household living in the area. Besides, factors influencing household food insecurity in the area are not yet known and documented before. This indicates that there exist information gap on the factors influencing rural household food insecurity to implement different food security programs. The main objectives of the paper were to identify status of household food insecurity, and to examine factors influencing rural households' food insecurity in the area.

Assessing factors influencing rural household food insecurity is very crucial as it provides information regardless of food insecurity status of the household level that helps the policy makers for effective implementation of food security programs. Besides, the output of this research may help development practitioners and policy makers to acquire better knowledge to carry out development interventions at the right time and the right place in rural areas to decrease vulnerability to food insecurity. In addition to this, the study may help to know and document the factors influencing household food insecurity in the area.

Food security is defined in different ways by international organizations and researchers. Food security is a situation that exists when all people, at all times have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). Food insecurity exists when this condition is not met. Similarly, Caraher and Coveney (2004) defined as, food poverty and food insecurity signify the inability to consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so. According to Andersen (2009), food security is used to describe whether a country has access to sufficient food to meet citizen's dietary energy requirements. Some experts used the term national food security to refer to self-sufficiency, means that the country has the ability to produce the food demanded by its population. Thus, food security is a multidisciplinary concept which includes economic, political, demographic, social (discriminatory food access), cultural (eating habits) and technical aspects. Making food security a reality therefore also implies to take into consideration the role of non food factors.

The international human rights approach then has critical potential to highlight food insecurity as symptoms of a system which fails both to ensure individuals and households have adequate income, and to ensure that what is available to purchase or consume, at affordable cost (that is, physically and economically accessible for all), is appropriate for health. There is a clear interdependence and indivisibility between the right to food and the right to health, as articulated throughout United Nations general comment 14 on the right to the highest attainable standard of health. This embraces a wide range of socio-economic factors promoting conditions under which people can lead a healthy life, as well as the underlying determinants of health including food and nutrition (CESCR, 2000).

Food security is commonly conceptualized as resting on three pillars: availability, access, and utilization. As Webb et al (2006) noted, these concepts are inherently hierarchical, with food availability is necessary but not sufficient to ensure access, which is in turn necessary but not sufficient for effective utilization. Availability reflects the supply side of the food security concept. In order for all people to have sufficient food, there must be adequate availability. But adequate supplies do not ensure universal access to sufficient, safe and nutritious food, nor do they ensure that the food to which people has access is used to its full potential to advance human health and well-being (Webb et al., 2006). Food availability solely does not assure access to food and enough calories do not necessarily guarantee a healthy and nutritional diet (Andersen, 2009).

Hence, the second pillar of the food security concept is access. Access is most closely related to social science concepts of individual or household well-being: what is the range of food choices open to the person(s)? It reflects the demand side of food security, especially as manifest in the role food preferences plays in the definition of food security. This is meant to capture cultural limitations on what foods are consistent with a population's prevailing values. Two people from different traditions with access to exactly the same diet might not consider themselves equally food secure given variation in religiously or culturally determined food tastes. Inter and intra household distributional questions also influence access (Webb et al., 2006). According to

Stamoulis and Zezza (2003), food access is access by individuals to adequate resources (entitlements) to acquire appropriate foods for a nutritious diet.

The third pillar of food security is food utilization. Utilization reflects concerns about whether individuals and households make good use of their food access. Do they acquire nutritionally essential foods that they can afford or do they forgo nutrient intake in favor of consumption of an inadequately varied diet, of non-food goods and services, or of investment in their future livelihoods? Are the foods they purchase safe and properly prepared, under sanitary conditions, so as to enjoy their full nutritional value? Do individuals have adequate access to preventive and curative health care so as to be free of diseases that can limit their ability to absorb and metabolize essential nutrients? In particular, over the past generation, widespread concerns have arisen about micronutrient deficiencies associated with inadequate intake of essential minerals such as iodine, iron or zinc, and vitamins, in particular A and D (Webb et al., 2006).

Some agencies, such as the United Nations Food and Agriculture Organization (FAO), consider stability to be a fourth dimension of food security. Stability captures the susceptibility of individuals to food security due to interruptions in access, availability or utilization. Certain individuals within communities or households may be more vulnerable to instability and are at greater risk of food insecurity. This matter for targeting of interventions and the design of safety nets intended to safeguard food security for vulnerable subpopulations (Christopher and Erin, 2009).

According to Renzaho and Mellor (2010), food security should be based on four inter-related pillars of food availability, food access, food utilization and asset creation. Asset creation is concerned with putting in place structures and systems that sustain a household's or individuals' ability to overcome sudden shocks which threaten their access to food including economic and climatic crises. Their conception of food security is not highly different from the general food security concept. They, for instance, explain that food availability is about the amount of food which is available through domestic production or import, including from food aid. Furthermore, Renzaho and Mellor explain that access to food means distribution nutritious food which can be accessed by all household members.

Renzaho and Mellor (2010), explain that food utilization comprises of physical utilization and biological utilization. Physical utilization is concerned with household's entitlement on physical means that can be used to utilize food, whereas biological utilization involved the ability of human body to absorb the nutrients from the food effectively. Therefore, food security is highly related with public health matters such as access to clean water, housing condition and sanitation. The last pillar is asset creation according to Renzaho and Mellor (2010) which is concerned with creating an enabling environment that able to protect individuals from a sudden shock that harms their access to food. It is built through certain structures and system that comprises of five different capital assets: human, natural, financial, social and physical. Examples of these capital assets for instance roads, water supplies, schools, food production, food processing and packaging, food marketing or market regulation, income transfer, affordable credits, trust, reciprocity, and social networks. In line with this concept, Braun (2009) stated that ensuring food security does not only require appropriate agricultural management and utilization of natural resources and eco-systems, but good governance and sustainable political system. This is obvious since food secures life and because the mission of national security is to secure society and defend its existence. This implies that food also an essential element of national security (Fullbrook, 2010). In addition, Fullbrook states that to secure food supply, it must be universally viewed not only as a commodity but as a security good. Food must be put as a priority above other activities and its positions must be recognized as an inviolable foundation of human existence and security.

MATERIALS AND METHODS

Location of the study district

The East Hararghe zone has 17 districts from which Babile is the one. It is located 35 km away from the city of Harar and about 555 km East of Addis Ababa. It lies between 8°, 9'- 9°, 23' N latitude and 42°, 15'- 42°, 53' E longitude. It shares its border with Gursum from the North, Fedis from the West, Harari National Regional State from the North West, and Somali National Regional State in the East, South, and South West (DARDO, 2011) (Figure 1).

Sampling techniques and methods of data collection

A two-stage random sampling procedure was used to select 150 sample rural households. Firstly, 4 kebeles were randomly selected from 21 kebeles of arid and semi-arid agro-ecological zones of the district. Secondly, based on probability proportional to size technique 150 sample rural households were randomly selected from the corresponding 4 kebeles of both arid and semi-arid agro-ecological zones. Both secondary and primary data collection methods were employed. The primary data required for this study was collected from sample respondents using structured questionnaire; data like Caloric intake and factors affecting food insecurity were the major once. Data collection was started after pretest was conducted and modifications were made.

Methods of data analysis

Measuring food insecurity status

The major food types used are sorghum, maize, ground nut and sweet potato. Animal products, fruits and vegetables are rarely consumed by rural households in this area. The common ways of acquiring food were own-farm production and purchase from markets. Other ways of acquiring food include gifts, food loans and

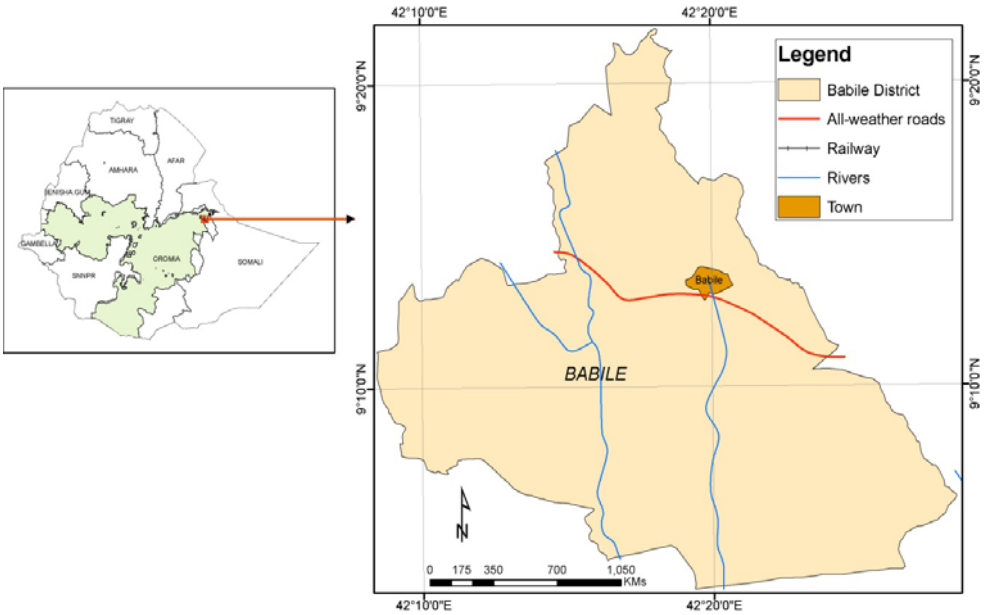

Figure 1. Map of Babile district, East Hararghe zone, Ethiopia.

Table 1. Conversion factor to calculate adult equivalent (AE).

Sex	Age	Adult equivalent (AE)
Boys	<13	0.4-0.80
Girls	<13	0.4-0.88
Male youth	13-18	1.0-1.20
Female youth	13-18	1.0
Male	19-59	1.0
Female	19-59	0.88
Old Male	>59	1.0
Old Female	>59	0.80

Source: Gassmann and Behrendt (2006).

food aid from governmental or nongovernmental Organizations.

Data on a household's caloric acquisition per adult equivalent per day were obtained on available food consumption from purchase and stock for two periods (before and after harvest) to the households. This is because measuring food insecurity status at the household level by direct surveys of dietary intake in a single period doesn't take in to account the down ward risks that rural households might face. The down ward risk might be resulted in the level of, and changes in, socioeconomic and demographic variables such as real wage rates, employment, production, price ratios and migration, etc. Thus, to taken in to consider these downward risks that rural households might face, collecting the amount food that rural households consumed in two periods (that is, before harvest season as first period for seven days and after harvest season as second period for 7 days) and calculating average calorie intake per adult equivalent of each sample households in both period is better way of measuring food insecurity status.

The information was obtained from the household member that is knowledgeable in the preparation and consumption of the commonly used instead of kilogram and/or liter were converted in to a standard metric system and to do that conversion factor were calculated between metric units and local units. Firstly, the amount of food consumed was converted in to calorie for the periods of one (before harvest season in the month October for the seven days) and period of two (after harvest season in the month of January for the seven days) with the aid of standard nutrient composition table, then divide the calorie intakes of each sampled household in to seven in order to obtain daily calorie intake of each selected households for both periods. Secondly, the household's daily calorie intakes per adult equivalent (calorie per AE per day) for both periods were calculated by dividing the daily caloric intakes by the family size after adjusting for adult equivalent using the consumption factors for age-sex categories. Thirdly, the average households' daily calorie intake per adult equivalent was calculated. In order to calculate the average household's daily calorie intake per adult equivalent (calorie per AE per day) for two periods, the sum of each household's calorie intakes per adult equivalent (calorie per AE per day) for the two periods were divided by two. The calculation of AE for food consumption takes into account the household through recall. The local units that rural households

Table 2. Descriptive statistics of dummy variables.

Food Insecurity status						
Variable	**Description**	**Food insecure**	**%**	**Food secured**	**%**	**Chi-square (χ^2)**
Eduhhh	Illiterate	66	44	38	25.3	6.376**
	Literate	19	12.7	27	18	
Improvvari	User	18	12	42	28	29***
	Non user	67	44.7	23	15.3	
Pestinfes	Yes	62	41.3	22	14.7	22.84***
	No	23	15.3	43	28.7	
Off/Nonfarm	Yes	30	20	40	26.7	10.20***
	No	55	36.7	25	16.7	
Irrigatscheme	Yes	2	1.4	5	3.3	2.36*
	No	83	55.3	60	40	

*, ** and*** significant at less than10, 5 and 1%, respectively (Source: Own computation result, 2012).

Table 3. Descriptive statistics of continuous variables.

Variable	**Food insecurity status**				**t-value**
	Food insecure HHS		**Food secure HHs**		
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	
Age	36.25	7.51	39.09	7.80	2.32**
Famesize	5.29	1.63	4.80	1.52	-1.82*
Sizecult	1.17	0.67	1.45	0.88	-2.13**
Totfarin	4,474	2,978	6,965	4,504	4.06***
Hhexpend	6,822	3,337	7,972	3,162	2.14**

*, ** and*** significant at less than10, 5 and 1%, respectively; (Source: Own computation result, 2012).

age and sex of the household members, as described by Gassmann and Behrendt (2006) (Table 1).

To identify food insecure households and analyze the contributing factors of food insecurity an international minimum calorie requirement was used as cutoff point between food insecure and secure households. Thus, households whose average daily per capita intake higher than or equal to 2200 Kcal per adult equivalent per day (recommended per capita daily calorie intake), were considered as food secure where as those whose average consumption is below 2200 kcal per AE per day were considered as food insecure households.

Analytical models

The food insecure status of sample households was determined using descriptive statistics. Factors influencing household food insecurity were analyzed using Descriptive statistics and Binary Logit Model (Tables 2 and 3). The results of significant variables using descriptive statistics are follows:

Following Gujarati (1995); Aldrich and Nelson (1984); Hosmer and Lemeshow (1989); the functional form of logistic model is specified as follows:

$$P_i = E(Y=f/x) = 1$$

$$P_i = E\ (y = 1/x) = \frac{1}{1+e^{-(B_0+B_1X_1)}} \quad (1)$$

For ease of exposition, we write (1) as:

$$P_i = \frac{1}{1+e^{-zi}} \quad (2)$$

The probability that a given household is food insecure is expressed by (2), while the probability for food secure is:-

$$1-P_i = \frac{1}{1+e^{z_i}} \quad (3)$$

Therefore, we can write as:

$$\frac{P_i}{1-P_i}=\frac{1+e^{Z_i}}{1+e^{-Z_i}} \quad (4)$$

Now $\left(\frac{P_i}{1-P_i}\right)$ is simply the odds ratio in favor of food insecurity. The ratio of the probability that a household will be food insecure to the probability of that it will be food secure. Finally, taking of the natural log of equation (4) we obtain:

$$\text{Li}=\ln\left[\frac{P_i}{1-P_i}\right]=Z_i=\beta_0+\beta_1X_1+\beta_2X_2+....+\beta_nX_n \quad (5)$$

Where P_i = is the probability of the household to be food insecure; $1-P_i=$ is the probability of the household to be food secure; $Z_i=$ is a function of n explanatory variables (x) which is also expressed as:

$$Z_i=\beta_0+\beta_1X_1+\beta_2X_2+.....\beta_nX_n \quad (6)$$

$\beta_0=$ is an intercept; $\beta_1,\beta_2,....\beta_n$ are slopes of the equation in the model; Li = is log of the odds ratio, which is not only linear in X_i but also linear in the parameters; X_i is vector of relevant household characteristics If the disturbance term (U_i) is introduced, the logit model becomes:

$$Z_i=\beta_0+\beta_1X_1+\beta_2X_2+.....\beta_nX_n+U_i \quad (7)$$

The dependant variable in this study is food insecurity which is dichotomous dependent variable in the model taking value of 1 if a household is food insecure and 0 otherwise.

Explanatory variables

Family size (FAMESIZE): This refers to the total number of family members of the household in adult equivalent (AE). It was expected that family size and household food insecurity associated negatively.

Age of household head: It was measured in number of years. Rural households devote most of their time or base their livelihoods on agriculture. The older the households head the better he/she has social network as well as the more experience on farming and weather forecasting. Thus, it was hypothesized that household head age has negatively related to household food insecurity.

Educational status of the household Head (EDUSTATUS): This is a dummy independent variable taking the value 1 if the household head is literate, 0 otherwise. It was expected that education status of the household head will have negative association with household food insecurity.

Size of cultivated land (SIZECULT): This is a continuous variable representing the total landholding of the household measured in hectares. It was expected that size of cultivated land will have negative association with household food insecurity.

Access to improved variety (IMPRVAR): This is a dummy independent variable taking the value 1 if the household uses improved variety, 0 otherwise. It was expected that access to improved variety negatively associated with household food insecurity.

Off-farm/Nonfarm income (OFFNONFI): This is a dummy independent variable taking the value 1 if the household participate in off/none farm income sources, 0 otherwise. Participation in non/off-farm activities was expected to be negatively associated with household food insecurity.

Annual farm income (TOTFARIN): Farm income can be defined as the total annual income earned from farm produces i.e. livestock and crop production in Birr. It was hypothesized that farm income and food insecurity status of a household will have negative association.

Annual household expenditure (HHEXPEND): The proportion of income spent on food expenditure matters the status of household food insecurity. The proportion of income spent on food expenditure matters the status of household food insecurity. It was hypothesized that proportion of food expenditure and food insecurity are related negatively.

Insect and pest infestation (PESTINFEST): Insect and pest infestations are important biological factors restraining crop production and causes of food deficit in the study area. In light of this, it was hypothesized that insect and pest infestations will have positive association with food insecurity status of the households.

Use of irrigation scheme (IRRIGSCME): is a dummy variable in the model taking value of 1 if the household uses irrigation and 0, otherwise. It was expected that use of irrigation scheme and household food insecurity are negatively related**.**

RESULTS AND DISCUSSION

Descriptive results

Food Insecurity status of the households

Using 2200 kcal per AE per day as a benchmark to classify food insecure and secured sample households, 85 sample households were found to be unable to meet the minimum subsistence requirement and 65 sample households met the minimum subsistence requirement. In other words, 57 and 43% of the sample households were food insecure and food secure, respectively.

Econometric results

The econometric results of hypothesized variables were presented using binary logit model. This model was used to identify potential explanatory variables affecting household food insecurity through maximum likelihood (ML) estimates. Before running the analysis, it was necessary to check for the existence of multicollinearity among continuous variables and verify the degree of

Table 4. Maximum likelihood estimates of binary logit model.

Variable	Coefficient	Z	Significance
Constant	.3973121	0.25	0.801
Age	.0099781	0.29	0.775
Famsize	-.2173352	-1.23	0.219
Educstatu	-1.091609	-2.05**	0.040
Sizecultilan	-.7317101	-1.95*	0.051
Annfarmin	-.0001918	-2.71***	0.007
Annexpend	.0000834	1.02	0.306
Offnon	-.16031	-0.32	0.747
Imrvari	-.4256152	-0.64	0.521
Irrgschme	-2.466635	-2.10**	0.035
Pesinfest	1.495444	3.20***	0.001

Log likelihood = -48.743881; Number of Observation (N) =150; Log likelihood ratio value: $\left(\chi^2_{df=18}\right)$ = 86.10 *** Pseudo R^2 = 0.8229; *, ** and*** significant at less than10%, 5% and 1%, respectively; (Source: model output, 2012).

association among dummy variables. Variance inflation factor and contingency coefficient were computed to detect multicollinearity for continuous variables and high degree of association for dummy variables respectively.
It is possible to conclude that there were no multicollinearity and association problems between set of continuous and dummy variables as the respective coefficients were very low. This shows that for all continuous explanatory variables the VIF was less than 10 (Table 6). For dummy explanatory variables CC was less than 0.75, which revealed the absence of a severe multicollinearity problem among potential explanatory variables (Table 7).

Factors affecting household food insecurity

With the exception of Linear Probability Model, estimation of binary choice models usually makes use of the method of maximum likelihood (Table 4).

Explanation of significant explanatory variables

Size of cultivated land: Production or output can increased either by intensification or by using higher size of cultivated land. As the cultivated land size increases, the likelihood that the holder gets more output is high. Size of cultivated land negatively and significantly affected the household food insecurity at less than ten percent probability level. The negative sign of size of cultivated land indicates that the size of cultivated land increases, the likelihood of the household to be food insecure will decline. This result coincides with the findings of (Frehiwot, 2007).

Annual farm income: Availability of farm income helps the farmers to purchase agricultural inputs like fertilizers and improved varieties. Therefore, the more rural households use improved technologies, the higher the probability to increase production and productivity, and consequently achievement of food security. The result of the regression analysis indicates that annual farm income negatively and significantly influences household food insecurity at less than one percent probability level. The negative sign of annual farm income indicates that annual farm income increases the likelihood of the household to be food insecure will decrease. Similar study was reported by (Belayneh, 2005).

Irrigation scheme: It was hypothesized that use of irrigation scheme negatively associated with the household food insecurity. The result of the regression analysis supports this hypothesis. Use of irrigation scheme negatively and significantly affected the household food insecurity at less than five percent probability level. The negative sign of use of irrigation scheme indicates that when the households continue in use of irrigation scheme, the likelihood of the household to be food insecure will decrease.

Insect and pest infestation: Pests are one of the constraints of food security in the rural society (Ehrlich, 1991). It was hypothesized that insect and pest infestation have a positive association with household food insecurity. The result of the regression analysis supports this hypothesis. The result of the analysis indicates that insect and pest infestation problem positively and significantly affected the household food insecurity at less than one percent probability level. The positive sign of insect and pest infestation indicates that insect and pest infestation problem persists in the area, the likelihood of the household to be food insecure will

Table 5. Marginal effect of significant explanatory variables.

Variable	Change in the probability of food insecurity	Z	P>|z|
Educatio	-.2603695	-2.07	0.039
Annfarmin	-.0000448	-2.69	0.007
Irrgschme	-.5158117	-3.39	0.001
Pesinfest	.3435646	3.40	0.001
Sizecultil	-.1710421	-1.98	0.048

Change in the probability of food insecurity is calculated at the mean values of Xs.

Table 6. Variance inflation factor test for continuous variables.

Factor	Variable	1/VIF
Age	1.19	0.84
Family size	1.47	0.68
Dependency ratio	1.17	0.85
Farm Income	1.14	0.87
HH expenditure	1.37	0.73
Size of cultivated land	1.05	0.95
TLU	1.12	0.89
Asset possession	1.13	0.88
Mean VIF	1.21	

increase.

Educational status of the household head: Education may help rural people to be easily equipped with new ideas, thinking, and technology that help them to change their negative attitude in to positive once. The result of the regression analysis indicates that educational status of the household head negatively and significantly influences the household food insecurity at less than five percent probability level. The negative sign of educational status indicates that as rural households' continue in upgrading their educational status, the likelihood of the household to be food insecure will decrease. This result coincides with the findings of (Frehiwot, 2007).

Marginal effect of significant explanatory variables

In binary logit model, the changes in probabilities (slopes) can be computed, though not constant, and are termed as marginal effects or the change in log-odds ratio for a unit change in a covariate. In this study the changes in probabilities (slopes) computed by using marginal effects (Table 5).

Size of cultivated land: The marginal change in the size of cultivated land influenced negatively to the probability of food insecurity. The computed result indicates that if the size of cultivated land increases by one hectare, then decreases by 0. 171 when all other variables held at their mean values. With increasing population land size per household member will not increase. So when land size /person decreases, the food insecurity increases.

Annual farm income: The marginal change in annual farm income influenced negatively to the probability of food insecurity. The computed result indicates that if the annual farm income of the households increases by 1000 unit, then the probability of the households to be food insecure decrease by 0. 0448 when all other variables held at their mean values.

Use of irrigation scheme: The marginal change in use of irrigation scheme influenced negatively to the probability of food insecurity. The computed result indicates that if the sample households keep using irrigation scheme, then the probability of the household to be food insecure decreases by 0.516 when all other variables held at their mean values.

Insect and pest infestation: The marginal change in insect and pest infestation problem influenced positively to the probability of food insecurity. The computed result indicates that if insect and pest infestation problem persists in the area, then the probability of the household to be food insecure increases by 0.346 when all other the probability of the households to be food insecure variables held at their mean values.

Table 7. Contingency coefficient test for dummy variables.

Variable	EDUS	IRSE	IRRIC	EXTE	CRE	OFFN	PEST
Edus	1.000						
Irsee	-0.165	1.000					
Irric	0.010	0.012	1.000				
Exte	-0.089	0.238	0.076	1.000			
Cred	0.081	-0.028	0.089	0.076	1.000		
Offn	-0.102	0.300	-0.016	0.150	0.066	1.000	
Pesti	0.022	-0.180	-0.122	-0.045	-0.028	-0.059	1.000

Educational status of the household head: The marginal change in educational status of the households influenced negatively to the probability of food insecurity. Educational status of the household favor the probability of the household to be food secure. The computed result indicates that if the sample households keep in upgrading their educational status, then the probability of the households to be food insecure decreases by 0.260 when all other variables held at their mean values.

Conclusions

The finding of the study indicates that 57% of samplehouseholds were unable to meet the minimum average daily calorie intake per adult equivalent. These food insecure households couldn't obtain the required average daily minimum calorie requirement from their production, purchase, or stock they had. Moreover, their participation in off/nonfarm activity, utilization of irrigation scheme, utilization of improved variety, and their educational status couldn't take out of them from food insecurity status. In addition to this, the existence of insect and pest infestation was significant in the district that inhibits their effort to be out of food insecurity.

The results of econometric analysis for the factors of household food insecurity have shown that the direction and influence of various factors on household food insecurity has varied. Educational status of the household head, annual farm income, use of irrigation scheme, and size of cultivated land associated negatively. Whereas, insect and pest infestation demonstrates positive and significant association with household food insecurity. Finally, the results of econometric analysis made it clear that these factors were the major factors of household food insecurity.

RECOMMENDATIONS

1. Size of cultivated land and household food insecurity associated negatively. However, population increases beyond the carrying capacity of land which fastens the vulnerability of rural households towards food insecurity. Therefore, measures such as appropriate land use, improved technologies and proper extension services should be in place to raise existing land productivity.
2. As annual household farm income and food insecurity are associated negatively on the model result, searching and providing productive technical skill that make farmers competitive on the current farming system and generate income should be sought and promoted. Farm income-food insecurity relationship leads to propose high value of cropping pattern.
3. It was found that insect and pest infestation and household food insecurity associated positively. Thus, provision and awareness creation about different biological and chemical conservation measures should be provided so as to reduce the problem. Therefore, governmental and nongovernmental organizations that are working in the area should give due attention to reduce the problem.
4. The result of the analysis indicates that the use of irrigation scheme and household food insecurity associated negatively. Therefore, the agricultural and rural development office and nongovernmental organization that are working in the area should encourage, facilitate and strengthen the farmers to use small scale ground water irrigation activities so as to increase food production and reduce food insecurity.
5. Educational status of the household head in relation to food insecurity confirms that negative and significant. Therefore, farmer training centers should give due attention in strengthening the already provided training to the farmers to change their attitude and upgrade their production potential. In addition to this, strengthening informal education and vocational or skill training should be promoted.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Aldrich J, Nelson FD (1984). Linear Probability, Logit and Probit Models: Quantitative applications in the Social Science: Sera Miller McCun Sage pub Inc., University of Minnesota and Iowa.

Andersen PP (2009). Food security: definition and measurement. Food Security (2009) 1:5-7.

Belayneh B (2005). Analysis of Food Insecurity Causes: The case of Rural Mete Woreda, Eastern Ethiopia, School of Graduate studies, Haramaya University

Braun JV (2009). Addressing the food crisis: governance, market functioning, and investment in public goods. Food Security1:9-15.

Caraher M, Coveney J (2004). Public Health Nutrition and Food Policy. Public Health Nutri. 7:591-598.

CESCR (Committee on Economic, Social and Cultural Rights) (2000). General Comment 14: The right to the highest attainable standard of health. UN Doc. E/C.12/2000/4.

Christopher BB, Erin CL (2009). Chapter for the International Studies Compendium Project, Robert, Cornell Univ. CSAE (Centre for Studies of African Economies) (2010). Department of Economics Oxford University Oxford, United Kingdom.

DARDO (2011). District Agricultural and Rural Development Office.

FAO (2002). The State of Food Insecurity in the World 2001. Rome: FAO, pp. 4-7

Frehiwot F (2007). Food insecurity and its determinants in Amhara region, School of Graduate Studies, Addis Ababa University.

Fullbrook D (2010). Food as security. Food Security. 2:5-10. http://dx.doi.org/10.1007/s12571-009-0050-y

Gassmann F, Behrendt C (2006). Cash Benefit in Low Income Countries: Simulating the Effects on Poverty Reduction for Senegal and Tanzania. Discussion Paper No. 15, Issues in Social Protection. Gebeva, Switzerland: International Labor Office.

Gujarati DN (1995). Basic Econometrics. Second Edition. MacGraw-Hill, New York.

Hadiprayitno II (2010). Food security and human rights in Indonesia. Dev. Pract. 20(1):122-130.

Hosmer D, Lemeshew S (1989). Applied Logistic Regression. A Wiley-Inter- Science Publication, New York.

International Fund for Agricultural Development (IFAD) (2010). 'Rural Poverty Report 2011: New realities, new challenges: new opportunities for tomorrow's generation'. Rome: IFAD.

Ministry of Agriculture (2012). Productive Safety Net APL III Additional Financing. Report No: 63924.

Renzaho AMN, Mellor D (2010). Food security measurement in cultural pluralism: Missing point or conceptual misunderstanding? Nutrition 26:1-9.

Shapouri S, Rosen S, Meade B, Gale F (2009). Food security assessment 2008–2009. Washington, DC: Economic Research Service, USDA.

Stamoulis K, Zezza A (2003). A conceptual framework for national agricultural, rural development and food security strategies and policies, ESA Working Paper No 03-17, FAO Agricultural and Development Economics Division, retrieved 5 March 2010

UNDP (2010). 'Human Development Report 2010: The Real Wealth of Nations: Pathways to Human Development', New York: Palgrave Macmillan.

USAID (2012). Ethiopia Food Security Outlook.

Webb P, Coates J, Frongillo EA, Rogers BL, Swingdale A, Bilinsky P (2006). Measuring Household Food Insecurity: Why it's So Important and Yet So Difficult to Do. J. Nutri. 136(S1):1404S-1408S.

World Bank (2011). 'Ethiopia: Country Brief', the World Bank Group.

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The geographical information system (GIS) use on development of genetically engineered plants: The world perspective and the USA enterprise (1997 to 2003)

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The world population will hit the nine billion mark by 2050. Environmentally sustainable agriculture developed in a way that safeguarded the Earth and still could feed all nations is needed. All things being considered, the fact remains that the entire species on Earth share a single interconnected ecosystem. Finding acceptable solutions for the environmental and natural resource management problems and at the same time curbing hunger is the goal. But, it requires analysis of many environmental issues done from cross-cultural, multinational, multidisciplinary, combinations of methods and comparative perspective. It is within this view that a development, analysis and discussion is made on the thorny but highly interesting subject of genetically engineered plants (GEP). It employed data search and literature perusal that helped in the interrogation of GEP world perspective. The geographical information system (GIS) analysis and mapping of the development of genetically modified organisms (GMOs) in USA from 1987 to 2003 was made. The results were suggestions on how knowledge on GMOs could better disseminated for informed worldwide view and curb scepticism based on fears of GMOs perceived risks of impacts which might be imposed on the environment. GMOs started in 1992 and today, USA has taken the lead in 45 States. The same crops planted with modern technology are still grown in areas designated by the Native Americans who used primitive methods that were totally dependent on the natural climatic conditions.

Key words: Dominant social paradigm (DSP), anthropocentric, unsustainable resource use, the new environmental paradigm (NEP), NEO-Luddites, Brownlash view, Lomborg school of thought, genetically engineered plants, biotechnology, genetic engineering, genetically modified organisms (GMOs), geographical information systems (GIS), traditional ecological knowledge (TEK).

INTRODUCTION

Biotechnology is a term used to incorporate many and varied biological discoveries for the development of industrial processes and the creation of useful organisms and their products. These include the production of foods

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and medicines, the reduction of wastes and the creation of renewable energy sources. All living things are made of tiny 'building blocks' called cells. Each cell contains inherited genetic recipes (genes). A gene is made of a length of Deoxyribonucleic acid (DNA) that has a message encoded in its chemical structure. Genes are the instructions that give organisms their characteristics. Although, the chemicals in DNA are the same for every living organism, the ordering or sequence of the chemicals varies and it is this variation that determines a plant's, animal's or an organism's physical make-up and features. Changes can be made to an organism by changing the sequence; turning off certain genes; or inserting new sequences (a whole gene). The terms genetic engineering (ge), or genetic modification (gm), or gene technology (gt) and/or genetic manipulation all refer to the transferring of single genes between differing plants and animals, or removing a gene from its original position and placing it into a new position in the same organism.

The objective and statement of the problem

Genetically modified organisms (GMOs) issue is difficult to comprehend by ordinary people; but yet poses a greater challenge to all the citizens of mother Earth. This is because it defied the fundamental fabric on which the mere existence of the entire planet hinges upon; more especially the ecosystems and biodiversity. This is why it had brought about a lot of inconsistent viewpoint. However, as a new scientific endeavour, it needed to be given a chance and this study attempt to do just that. The study analysed, weighted, compared and contrasted GMOs advantages and disadvantages from views coming from different sectors of life, more especially from agriculture. Then, better informed decision could be made about its safety or riskiness.

The aim of this study was three folds. First, it had put forward cross-cultural, multinational, multidisciplinary, combinations of methods and comparative perspective that tackled such a highly scientific, socially challenged complex issue which touched on all aspects of life. Data was collected by various methods that included telephone interviews whenever quick clarification was needed, perusal of written records, surfing the internet and web. The modern technology of geographical information system (GIS) was applied in assimilating and collating the data into digital database format. Then, the database was interrogated; assessed, analysed. The results were used to map the development of genetically engineered plants (GEPs) from 1987 to 2003. These maps were then used as assessment tools of the extent for GEPs' worldwide land cover/land use.

Second, this study highlighted the concerns about GEPs environmental and human health risks, which might be generated by embracing such a highly complex scientific endeavours without the fundamental knowledge and necessary infrastructure for its safe use. And third, mitigation procedures put in place by countries in order to minimise such risks was surveyed. The major concerns included lack of laws and insufficient security measures as effective GMOs risks monitoring tools. Also, the reactions by the United Nations (UN) on GEPs through its Food and Agricultural Organization (FAO) branch are alluded to (FOA - Economic and Social Development Department, 1995), (UNCED, 1992), (African Centre for Biosafety, 2012).

Background information

Throughout the Human Political and Economic Eras, from the Stone Age to the hunter's gatherers, through to the primitive farming communities and the Industrial Revolution mankind have been imprudently exploiting the natural resources for their own survival. Towards the end of the last of these first three eras, the Industrial Revolution, the notion was that there was an abundance of resources, and if there was any problem, science will fix it and more discoveries will be made. This dominant social paradigm (DSP) (Kilbourne and Polonsky, 2005), the anthropocentric believe that environmental policy and natural resources management practices ought to be directed towards the production of goods and services to benefit humans has long died off. But, this was not until after a substantial amount of damage had been done. The deterioration of marine fisheries caused by over-fishing was a consequence of population explosion with people needing land to live on and an increased amount of food to feed on. The consequences of these developments were diminishing riparian, seaside and coastal habitats as more and more of these lands were adapted into settlements and bigger nets were being thrown into the waters with increased frequency to catch more fish for food. The nongovernmental organizations (NGO) cries of "save the whales" were echoed from every corner of the planet, in the early 1980s by the Green Peace Movement. Today, the global nature of these threats to the environment is well understood.

The notion of sustainable resource use has taken off as a result of international, national and local scientists having taken the lead. Their endeavours at large are showing that, for the two centuries since the start of the Industrial Revolution, the human population has increased six-fold and economic activity is estimated to have exploded by fifty-fold. Consequently, this had resulted in increased carbon dioxide levels in the atmosphere, which has led to the green house effect. This had damaged the ozone layer and given rise to global warming, which in turn had caused the temperature to rise by about 0.10 to 0.60°C.

The significance of the anxiety about the deteriorating state of the Earth, and the agency to curb its continuing spread is reflected in various United Nations protocols (UN, 1972, 1992, 2002, 2007) and (UNFCCC, 2009) and these are also reflected in world list of protected areas

(Chape, Blyth, Fish, Fox, and Spalding, 2003). The United Nations has relentlessly made calls for sustainable development, environmental protection and the safeguarding of biodiversity and animal habitats. The major concern was the stand of GMO technology in all these. The present Era, the Information Age, had seen the growth of public awareness on the impact mankind was exerting on the environment and interrelationship between the human health, wellbeing, and the world around them. Pressure groups, many environmental lobbyists (African Centre for Biosafety, 2012), and individuals (Cahn, 1995; Van DeVeer and Pierce, 1994; Nap et al., 2003; Vig and Kraft, 2010; Vaughn, 2012), have called for better environmental and conservation laws and policies. They were at loggerheads with the producers and manufacturers who saw these changes as a threat to their companies' sustainability and valuable profits.

This new environmental paradigm (NEP) (Dunlap, 2008) was a new outlook that comprised such concepts as environmental protection, limits to consumption and economic growth, and a more sceptical view of science and technology. Hence, it was well understood that science is not "Ms Fix It" as it was once thought. So, a lot of questions have been asked when the GMO technology came about many of which not favourable to that course of action. And there have been doubts about it.

However, this study was to the belief that extreme care needed to be taken whenever such ground breaking discoveries like GMO. This is because science is "a two sharp sided needle, which can saw a garment and pierce the tailor's finger at the same time". Scientific knowledge often led to general societal progress, but human reason should be the ultimate standard of right and wrong. Of course, scientists must be free to follow the laws of reason in open society, logically ordered objective reality that people came to know about throughout the ages.

Also, this study understood that the scientists needed to include others in their endevours. For example, the traditional ecological knowledge (TEK) which shared much in common with scientific knowledge; although, it was more often than not considered unscientific. This study supported Donovan and Puri's notion that TEK had been developed on a trial and error basis, a form of hypothesis testing. This communiqué went on to say that although, TEK was not recorded and published, it had nevertheless been transferred by traditional multidimensional methods from one generation to the next (Donovan and Puri, 2004). So, the GMOs science needed to respects traditional knowledge, intuition, spirituality, the senses, human relationships, the work of the hand, the disorderly and unpredictable nature of reality as opposed to mechanistic or refluctionist construct of the world. An all-encompassing science could dispel some of the mistrusts levelled against some of the discoveries such as the GMO technology.

It was known that in rear occasions, personal feelings had influenced the problems scientists chose to make the subject of their study and what conclusion they drew. But, this was not enough reason to view scientific discoveries as little more than a clever means used to reinforce the authority of powerful' men and women; or being a NEO-Luddites. People should not fear changes, which comes with the new technology. So, GMOs must be taken with open mind, not only as an endevour that benefits large companies. In view of the arguments which were going on about GMOs, it was wrong for people to take brownlash view, the thinking that most scientist research concerning the environment was badly biased and inclined to overstate risks. It was also wrong as well for those who took the Lomborg school of thought, this was to the contrary; science was not used mainly for destructive purposes like high technology, nuclear power, powerful pesticides and fungicides, leading to the believe that GMOs posed serious threat to health and environment. It was in view of all these notions that this study was carried out.

The proposed approach or solution

Biotechnology is not a brand new enterprise; it has long being used by the forefathers in many ways, like traditional fermentation techniques which has been employed for decades in bread, making cheese and beer brewing. It has also been the basis of traditional animal and plant breeding techniques.

For instance hybridisation and the selection of plants and animals with specific characteristics to create, for example, crops which produce higher yields of grain and in animal husbandry, use of artificial insemination to produce best beef animals like the Brahman bull or best dairy animal like the Friesland Cow. What was new about biotechnology today was that researchers had taken a single gene from a plant or animal cell and inserted it in another plant or animal cell that gave the recipients desired characteristic, such as being repellent to specific and targeted insect pests for example the Coleoteran or Lepidopteran resistant, or Glyphosate tolerant plants; herbicides like Imidazolinone tolerant, or Phosphinothrin tolerant or Isoxazole.

These are: tolerant plants; environmental stress as well as quality traits such as improved post harvest storage; flavour such as yield increased; fertility altered, development altered and germination increased, drought tolerant; seed quality altered, cold tolerant; altered amino acid composition; protein altered; maturity altered; senescence altered, male sterile or increased stem strength; nutritional content such as tryptophan level increased; oil profile altered; yield altered, yield increased, phytote reduced; starch metabolism altered, lysine level increased; carbonhydrate metabolism altered, animal feed quality improved; nitrogen metabolism altered, seed size increased or fumonisin degradation, and colour change such as visual marker or kanamycin resistant.

Biotechnology could also be employed to manufacture industrial as well as pharmaceutical compounds as renewable resources with a production system based on solar energy. Examples of those are Anthocyarin

production seed, gene expression altered, pharmaceutical proteins produced, novel protein produced, industrial enzyme production, recombinase produced, transposon, coloured sectors in leaves, transposon inserted, seed colour altered, anthocyarin sequestration suppressed. Genetic engineering, or gene technology, has revolutionized agriculture, food technology, medicine and environmental management. Its aim was to make a living thing perform a specific useful task. This could be to fight disease, produce more food, or simply to make a flower blue.

Gene technology enables scientists to produce varieties of plants and animals with desirable characteristics in more precise and efficient ways than are possible using conventional breeding techniques. This is because genetic engineering allows the identification of genes, which give organism particular characteristics and transfer these genes into a different living thing. An added characteristic of gene technology is that it allows genes to be transferred between species, something that occurs only rarely in nature. The ability to transfer genes between species means that scientists can select from a larger number of genes for desired characteristics than is possible using traditional breeding.

There are many questions and concerns surrounding biotechnology. In order to find solutions, this study will take an approach of discussing possible answers to the following thirteen questions, in four subcategories that hold particular interest for this paper:

Who are the main producers of GMOs, where are they produced, since when and for how long have they been in the market?

a) How GEP is planted, by whom, where, when and how much?
b) Which are the major GMOs crops of the world?

Are there sufficient rules governing the production of GMOs and how effective are those in safeguarding from the risks?

a) Are companies subject to any penalties if they break rules governing GMOs?
b) Does the fact that genetically modified crops are owned by multinationals mean that these international agribusiness companies could eventually gain total control of the rights of seeds which are the national traditional ecological knowledge and what local farmers stood for generations; providing food for their families?
c) Are the productions of GMOs humanitarian driven to alleviate hunger in Africa as the popular media advocates for or are they driven by the economic desire of the international mega agribusiness companies who are eager to take advantage of the *Globalisation* and monopolise the now worldwide expansion of economic markets?
d) What are the major risks in placing animal genes in plants and vice versa?

Are genetically modified (GM) foods safe?

a) Can genetically modified foods cause allergies in some people?
b) Can genetically modified organisms escape into the environment?
c) Who is responsible for regulating GMOs?
d) What is the approval process that food companies or agribusiness firms must follow to get GM food products onto the market?

Are the genetically engineered plants grown in the same regions as was followed by the Native American of long time ago?

a) Are the genetically engineered plants grown in the same regions as was followed by the Native American of long time ago?
b) Are the crops of cotton, rapeseed, and cotton, planted with modern technology still grown in areas designated by the Native Americans who the primitive methods and followed the natural climatic conditions?
c) Suggest the reason for the answer?

MATERIALS AND METHODS

The materials and methods for this study were divided into four parts:

a) The first part was on data collection which was fundamental to the study information,
b) The second part was to analyse these information into three segments. One segment was to answer the worldwide twelve questions listed above. The other two segments are in the form of table. One table was specifically created as the attribute information on the GMOs development and production in the world perspective. The four mostly produced GMOs crops were worked out. And the second table dealt with the USA four mostly produced GEPs,
c) The third part was to use the attribute tables above to produce the USA land use/land cover change maps for the four GMOs crops from 1997 to 2003 with GIS applications,
d) The fourth part was to apply statistical procedures for the assessment of whether in the USA, there was a significant shift in the areas where particular crops were planted using primitive native America methods to where these crops are grown now with the use of modern biotechnology methods.

Data collection and its analysis

First and foremost, data on GMOs was collected. The methods used were data which came from various sources which included written records perusal, internet and web surfing, archival maps and telephone interviews for quick on the sport clarification. The data collection and its analysis was a mammoth task as the researcher had to do an extensive work on reading, data translation and interpretation. That was a challenge indeed as the sheer volume of information on GMOs was just overwhelming. Most of the information for the USA came from the Field Test Releases database: Http://www.isb.vt.edu/, (ISB, 2010). The database for USA

and International Field Tests of GMOs, information system for biotechnology, A National Resource in Agbiotech Information was useful. For other countries, data was sourced from the then current status of transgenic plants and from the latest GMO web news releases (ISAAA, 1991; EC, 2012).

Data processing for GMOs crop prevalence and their area of coverage

The second step was to sort out this data into dates and then categorized it into divisions by continents, regions, countries, states and counties or districts. Then, the main part came; the data was processed into information by reading and further categorizing it into units of questions the information might answer. At the end, there were three segments created. One segment was on answers to the extent to which biotechnology has developed; the issues on of GM foods; and information about the main producers of GMOs, where they produced, since when and for how long they have been in the market. The two segments were two attribute tables' one on the world GMOs and the other on the USA GMOs and its developments in different states.

The GIS applications and analytical map creation

The technique of GIS was used in creating a database attribute files. These were then transformed into a GIS by building topology whereby the two attribute tables were linked to the topographical map of the world and that of USA, respectively. Maps showed trends in the fast growing development of the GMOs technology for the world perspective and for the land use/land cover change (LULCC) for the USA were created for four crops and using five traits. These maps were then used as analytic tools for the interpretation to the development of the GEPs from 1987 to 2003. The data was enhanced into information that could be used for better management of the resources. These maps were used directly as tools to make analysis of GMOs status and to give the results.

Statistical procedures employed-land used for specific crops

The Native Americans of long ago learned to interact with their environments in order to survive. For the most part, they adapted their ways of living to the geography around them instead of trying to change their surroundings to supply their needs, like it is done today. The Eastern woodlands supplied them with animals, fish, nuts and berries. The southwest was a mostly desert, with mountains and deep canyon. Native Americans could not rely on the few forests and animals available there. So, they raised crops; beans and corn for food and cotton to weave into clothing. In between the eastern woodlands and the desert southwest was the vast grassland of the Great Plains. Here, they relied on the buffalo for food, clothing and shelter. In the Pacific North West they relied on a number of resources.

Today, it is the information age, and GMOs on corn, soybeans, rapeseed and cotton are used. Irony, this study found out that these crops are still planted in the same places they had been grown by the Native Americans. Technology might have changed but the driving forces of climates, which determine which crops grow, were still the same.

The subjects used in this part of the study are the forty-five American states where GEPs are grown. The entire country was divided into its climatic regions, which are 1) Eastern Central (ENCen); 2) Mountains (Mtn), North Eastern (Neng), and Pacific (P); 3) South and Atlantic (Satl) and Western Central (WNCen). The amount of GEPs for each state was given for cotton, rapeseed, corn and soybeans. The GEP was taken as the response variable while the explanatory variables were the climatic regions, and the four plants of the cotton, the corn, the rapeseed and the soybeans.

The subjects were arranged into columns, first with the state name, then the GMFARMS totals, the climatic regions which are given numeric codes of 1, 2, and 3 as shown above and that was followed by the crops of the corn, cotton, soybeans and rapeseed column.

The question of interest to be answered here was: are the GEPs grown in the same regions as were followed by the Native American of long time ago to grow the same but natural processed crops? And that are the crops of Cotton, rapeseed, and cotton, planted with modern technology still grown in areas designated by the Native Americans who used the primitive methods and followed the natural climatic conditions?

The statistical procedures used were as follows:

i. First step is exploration using matrix of scatterplots; correlation matrix; residual plots after fitting tentative models: First, the cooks distance plot was used to see if any variable is greater than one. Then, the leverage plot was checked, this was followed by the Studentized residual plot and after that the cook's distance plot was checked,

ii. Second step is to employ graphics results and see if transformation is necessary and also if there are any Outliers: The case influence statistic was important because it helped to identify influential observations that may not be revealed graphically and it also divided the overall influence of an observation into what was unusual about its explanatory variable values and what was unusual about its response relative to the fitted model. The outliers were then eliminated.

iii. Third step in the statistical procedures was the Extra Sum of Squares: This step was done in order to see if it was necessary to remove the influential variable and if there was any significance.

iv. The summary of statistical findings is given: The overall significance of the interactive model is then checked.

RESULTS

This study found that biotechnology was a complex scientific endevour and many concerns from various angles have been raised about it. The most important fact was that it has revolutionalised agriculture forever and it has the potential to led society to progress by curbing hunger which is eminent given the population rate; it is a fact that more food will be needed. Despite that, some of the concerns given against it are not completely unfounded. One that concern is on food security; whether GMOs were just a ploy to place the patent to all the seeds of all the crops in the world in the hands of a few powerful' men and women to reinforce their authority. Other concerns are based on human health and environmental wellness risks that might occur. This section tried to find answers to these through its rigorous research.

The GMOs main actors and its development

The first country to grow the genetically modified organisms (GMOs) was China, which began with one item, the tobacco in 1992; and went up to twelve items in 1999 (Table 1). By that time, the industrial countries grew 82% of the global GEPs by area and the 18% being grown

Table 1. World GMOs Spectrum – 1992 to 1999.

S/NO	Country/Continent	1992 to 1995	1996	1997	1998	1999	2000	2001	2002	2003
		GMO crops soybeans, corn, cotton and canola								
		No of single items								
1	China	1	6		9	12				
		% GMOs planted								
2	Industrial					82				
3	Developing					18				
4	USA					72				
5	Argentina					16				
6	Canada					10				
7	China					1				
8	Australia					1				
9	South Africa									
10	Mexico									
11	Spain									
12	France									
13	Portugal									
14	Rumania									
15	Ukraine									
		World in million hectares								
16			1.7	11	27.8	39.9				
17		World Economically the sales of GMOs in million US$								
18		84	347	1113	2300					

in developing countries of Latin America, Asia and Africa. The main countries growing GEPs were USA, Argentina, Canada and China, they grew 99% of the world total by hectare and the remaining balance of GM crops was grown in eight countries: - Australia, South Africa, Mexico, Spain, France, Portugal, Rumania and Ukraine (Table 1 and Figure 1). There were three European Union (EU) countries growing the GM crops despite the continuing debate about GEP (EC, 2012).

According to ISAAA publications, the global acreage of the GEPs increased from 1.7 million hectares in 1996, to 39.9 million hectares in 1999 (Table 1). This was a substantial 23.5 fold increase in only four years (ISAAA, 1991). Soybean, corn, cotton and canola are the major GEPs on a global basis. In terms of traits; herbicide tolerance was the most prevalent at 71% in 1999, followed by insect resistance at 22%. In 1999, for the first time in the USA, stacked genes for insect tolerance and herbicide tolerance in both corn and cotton occupied 2.9 million hectares (Figures 3 and 4).

Economically the sales of GMOs had increased from US$84 million in 1995, with sales quadrupling in 1996 to US$347 million, tripling in 1997 to $1,113 million, and doubling in 1998 to reach US$2.3 billion (Table 1). In 1999, sales were estimated at US$3 billion (ISAAA, 1991).

The GMOs development in the USA

In 1986, the Co-ordinated Framework for Regulation (CFR) of Biotechnology specified the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture (USDA), the Environmental Protection Agency (EPA) and the Food and Drug Agency (FDA) were confirmed primary government agencies for regulating biotechnology in USA. Acquisitions of licences for GMOs are used as a measure for GMOs development. Although, China had an early start by 1997, USA was by far the world leader in GMOs. Soybeans, corn, cotton and rapeseed were the GEPs most planted. From 1989 about seventeen states acquired licences for planting soybeans with enhanced nutrition (Figure 2).

GMOs USA states and the technology development

In the next period ranging from 1998 to 2003, almost the same number of permits was acquired mostly by the same states as before with only additional of 7 new states. Almost the whole eastern half of USA was growing GEP soybeans with enhanced nutrition. In the period ranging from 1989 to 1997 almost the whole 50% of the eastern USA, except 10 states at most obtained permission to grow the Bt and RR soybeans. The states of Washington and California in the Pacific Northwest also joined these ranks. In the period ranging from 1989 to 2003 almost 50% of the eastern states obtained permits to plant the Bt and RR Soybeans. In the period 1989 to 1998 only four states obtained permits for the complex and/or the complex soybeans traits (Figure 2 Part 1-C). In the period

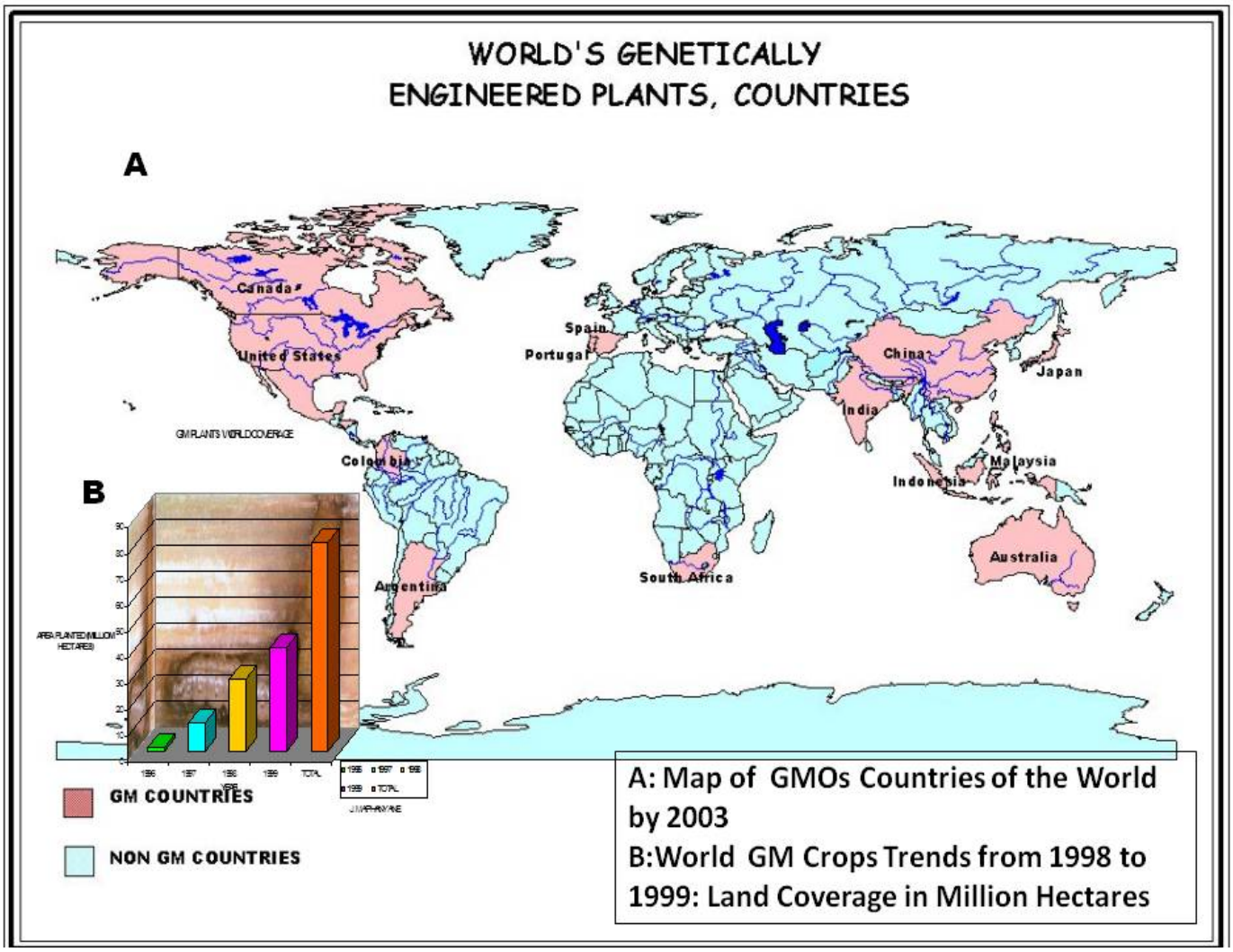

Figure 1. Map of the main leaders in biotechnology by 2003 and Graph showing its rapid development from 1987 to 2003.

1998 to 2003, there was a substantial increase in the licences obtained compared to the previous period, 12 states an almost in 75% increase that covered almost all the states in the eastern USA in the period 1989 to 1998. In the period 1989 to 1998, only one state obtained 10 permits for the Pharmaceutical soybeans. In the period 1998 to 2003, permits totalling 3 were obtained, this time for the Pharmaceutical soybeans. The number was four in the period 1989 to 1997 and this number increased to 8 states who obtained licences for changed yield soybeans. All these state are in the Central Eastern parts of the country. In the whole, more GEPs soybeans were grown in the period 1998 to 2003 than in 1998 to 2003. The most traits planted were Bt and RR followed by Nutrition trait (Figure 2).

In the period 1989-1897, almost one quarter of the total country states grew corn with enhanced nutritional traits (Figure 3 Part 2-C). Most of it was grown in the eastern half of the USA. The period 1998 - 2003 saw a substantial increase in the corn with these traits in the same region (Figure 3). In the period 1989 to 1997, all the central states had at least one pharmaceutical licence each, one state in the south and the two states of Pacific North West also obtained permits.

In the period 1989 to 1897, the eastern north quarter of the country were growing classified or complex corn traits, with two states, one in the south and the other in the Pacific North West joining their ranks. The period 1998 to 2003 saw a substantial dwindle in permits for these traits. In the period 1989 to 1897, the eastern north quarter of the country were growing corn with enhanced yield quality traits, with one state in the south and another one in the Pacific North West joining their ranks. The period 1998 - 2003 saw a substantial increase in the number of states producing such traits. Almost 75% of the country was affected.

The number of permits for corn trait of Bt and RR was very high, covering most of the country with the highest

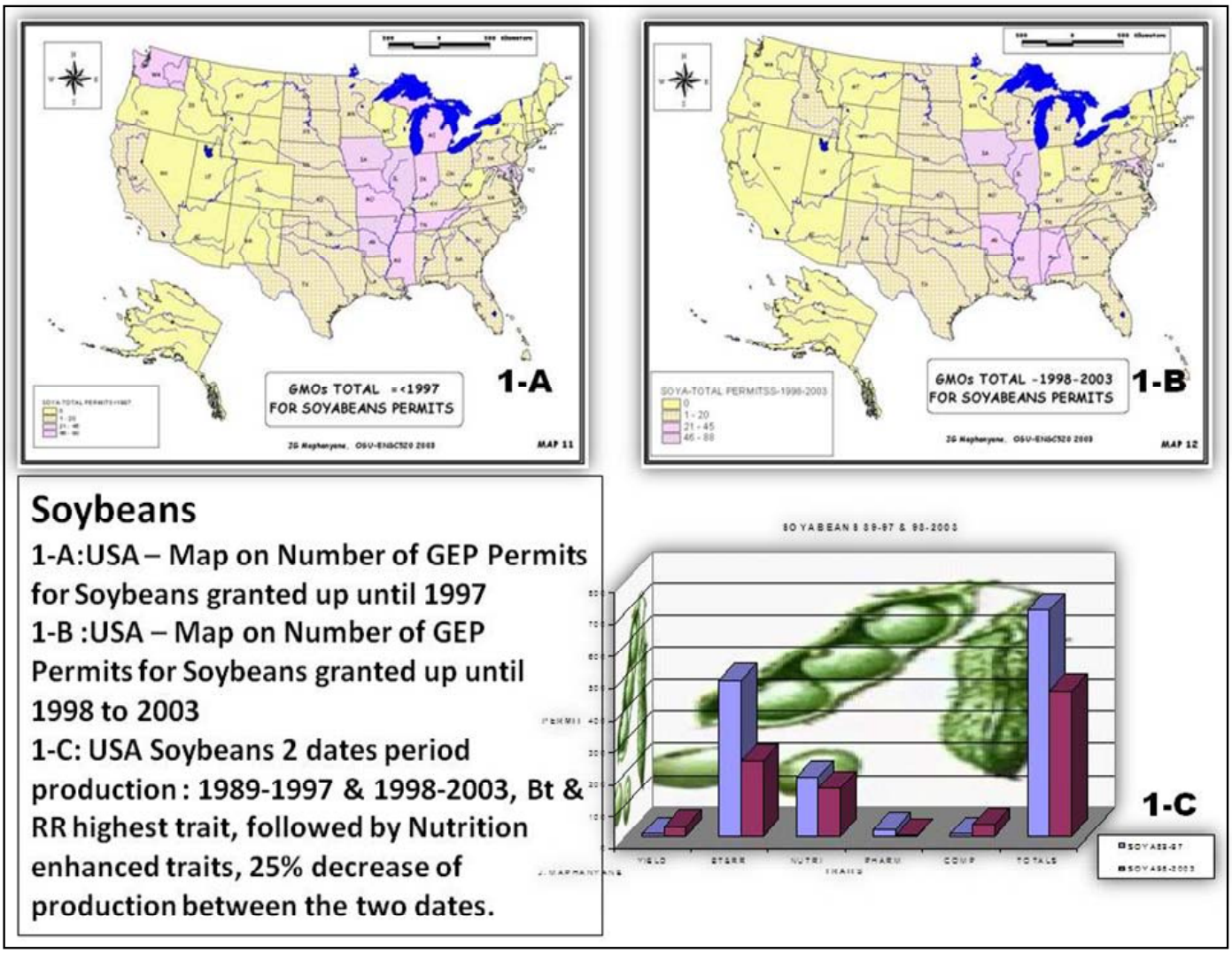

Figure 1. USA Maps of biotechnology permits granted for soybeans planting 1-A before and 1-B after 1987 to 2003 and its rapid development from 1987 to 2003 shown by 1-C Two periods graph of 1989-1997 and 1998-2003.

density in the eastern half of the USA. The period 1998 to 2003 saw a substantial increase not so in the number of new states who obtained the licence but on the large increase of the number of licences. The GM corn crop is grown in more than 70% of the US states with very highnumber of licences as well. The period 1998 to 2003 saw a substantial increase in the number of licences issued. There was an increase of little bit more than 100% of the previous number of licences (Figure 3). Four Southern and Western states obtained permits in the period 1989 to 1997 and this number increased to 9 states in the period 1998 to 2003 for changed yield of cotton permits (Figure 4). There was a few permits sort for other parts of the country. The states planting the nutritional cotton are very few and wide spread. Few permits were issued in the period 1998 to 2003.

There was a slight increase of permits obtained generally for growing GEP crops. These crops are mainly grown in the southern and western USA, with other few sites scattered all over the country. There is no pharmaceutical cotton gown but cotton grown is mainly Bt and RR (Figure 4 Part 3-C).

Initially, there was only one state growing GEP rapeseed. This was grown mostly in the north, some in the southeast and other being at the western parts of the country. These states mostly grew traits in Bt and RR followed very closely by Nutrition enhanced rapeseed.

The USA GMOs Free states

The following USA states have not embraced the new genetically engineered crop in their farming methods: New Hampshire (NH), Vermont (VT), District of Columbia (DC),

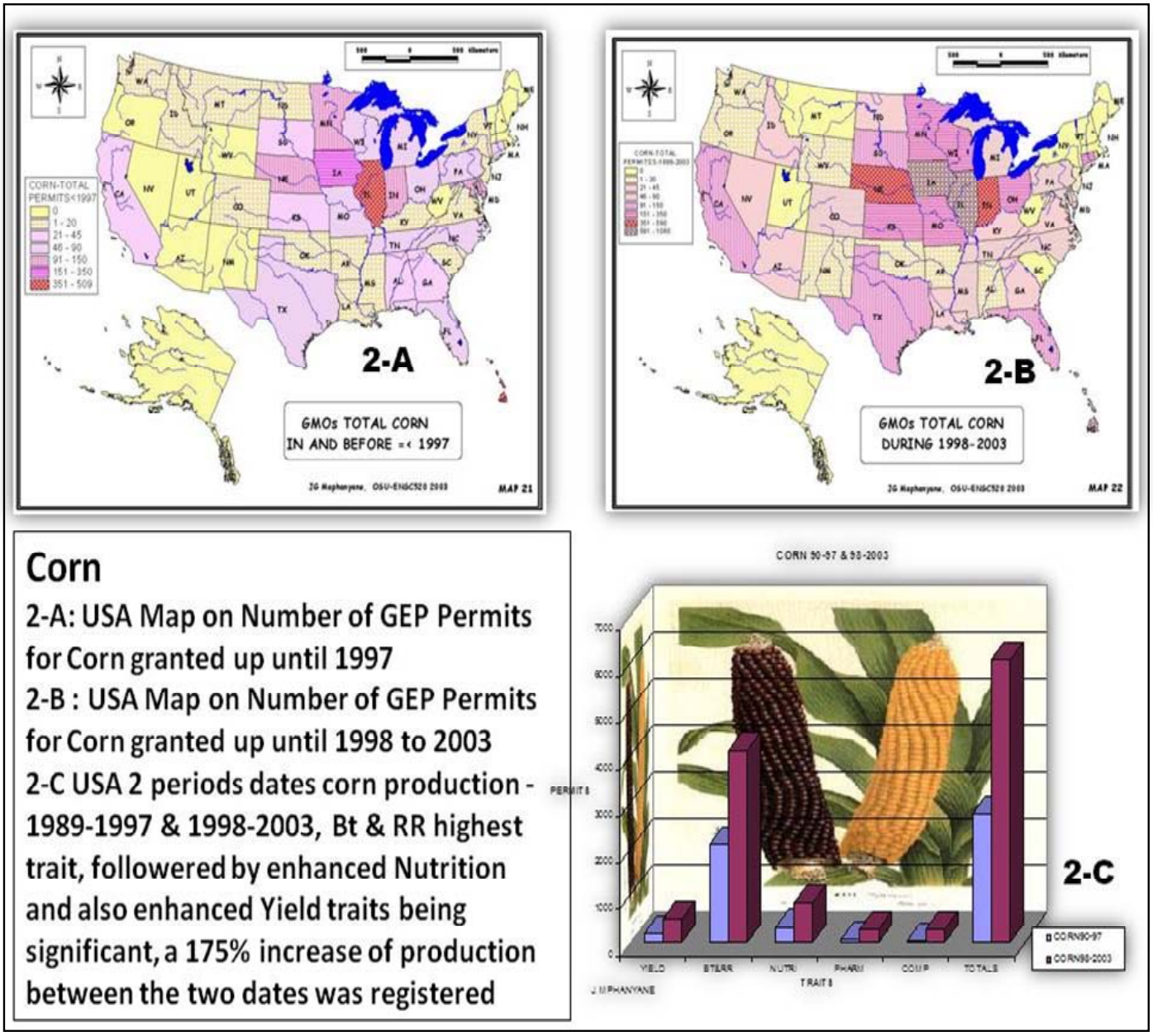

Figure 3. USA Maps of biotechnology permits granted for corn planting 2-A before and 2-B after 1987 to 2003 and its rapid development from 1987 to 2003 shown by 2-C Two periods graph of 1989-1997 and 1998-2003.

Massachusetts (MA), Utah (UT), West Virginia (WV), and Alaska (AK). AK is not farmable in any case, while DC is a City district where farming is limited any way, but NH, VT, MA, UT and WV are totally organic states (Figures 2, 3, 4 and 5).

Comparison of Native American farmland with GMOs sites

Today, using genetically engineered plants of corn, soybeans, rapeseed and cotton plant traits, they were still planted in the same places where they had been planted by the Native Americans. It seemed, technology might have changed but the driving forces of climates, which determine which crops grow where. There is convincing evidence that, specific food crops planted depends on the climatic conditions of an area, this includes those using the modern day farming with the genetically engineered plants traits.

The results of the study giving are as follow (Figure 6, Tables 4 and 5): F-stats is 7.6734 and a p-value of 0.0000685 and 95% Confidence Interval: t36 (0.975) = 2.0378.

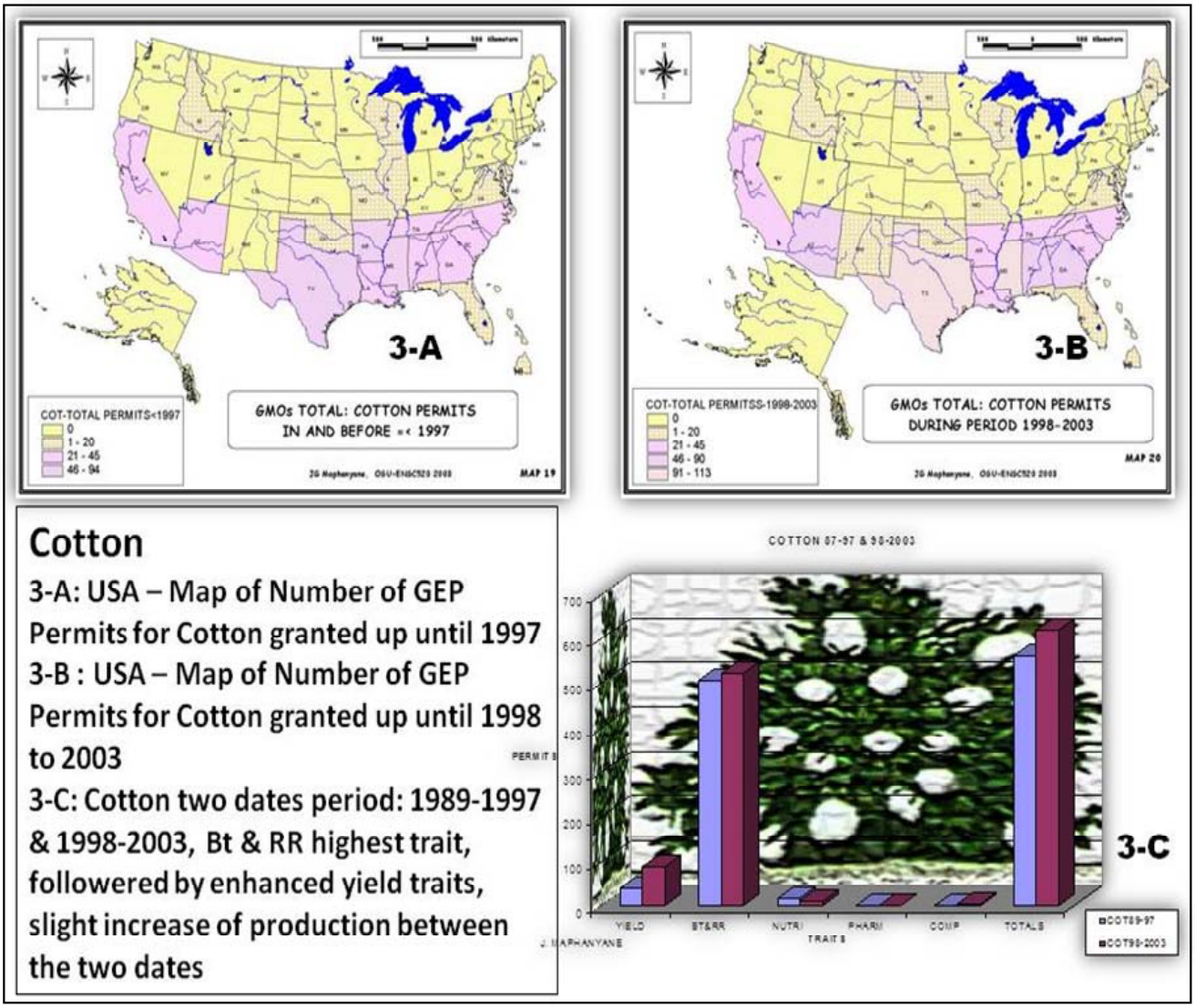

Figure 4. USA Maps of biotechnology permits granted for cotton planting 3-A before and 3-B after 1987 to 2003 and its rapid development from 1987 to 2003 shown by 3-C Two periods graph of 1989-1997 and 1998-2003.

(a) CODE 1.42887 +/- 2.0378* 0.34686 CODE = Climatic Region From 0.722038692 to 2.135701308
(b) CORN 2.01128 +/- 2.0378* 0.00497 CORN = Maize Crop From 2.001152134 to 2.021407866
(c) COT 1.56782 +/- 2.0378* 0.21850 COT = Cotton Crop From 1.1225607 to 2.0130793
(d) SOY 2.04033 +/- 2.0378* 0.01231 SOY = Soybeans Crop From 2.015244682 to 2.065415318
(e) RSED 1.32294 +/- 2.0378)* 0.05723 RSED = Rapeseed Crop. From 1.206316706 to 1.439563294

Important issues for GMO development

The success of GMO development and implementation with less risk to the environment are depended on stringent regulations. North America and European Community paved the general framework for a regulatory system. Many countries are now faced with the challenge to put up in place regulatory systems to ensure safe and effective evaluation of the impact of GEP crops. The United Nations Environmental Program (UNEP) issued international technical guidelines for Safety in biotechnology (UNEP, 1995). The UNEP-Global Environment Facility (GEF) project on the development of National Biosafety Frameworks was designed to assist countries to develop their National Biosafety frameworks so that they can comply with the Cartagena Protocol on Biosafety (UNEP-GEF, 2004). Currently 77 countries have enrolled.

Regulatory assessments are science, risk and case based. The USA regulation focuses primarily on the

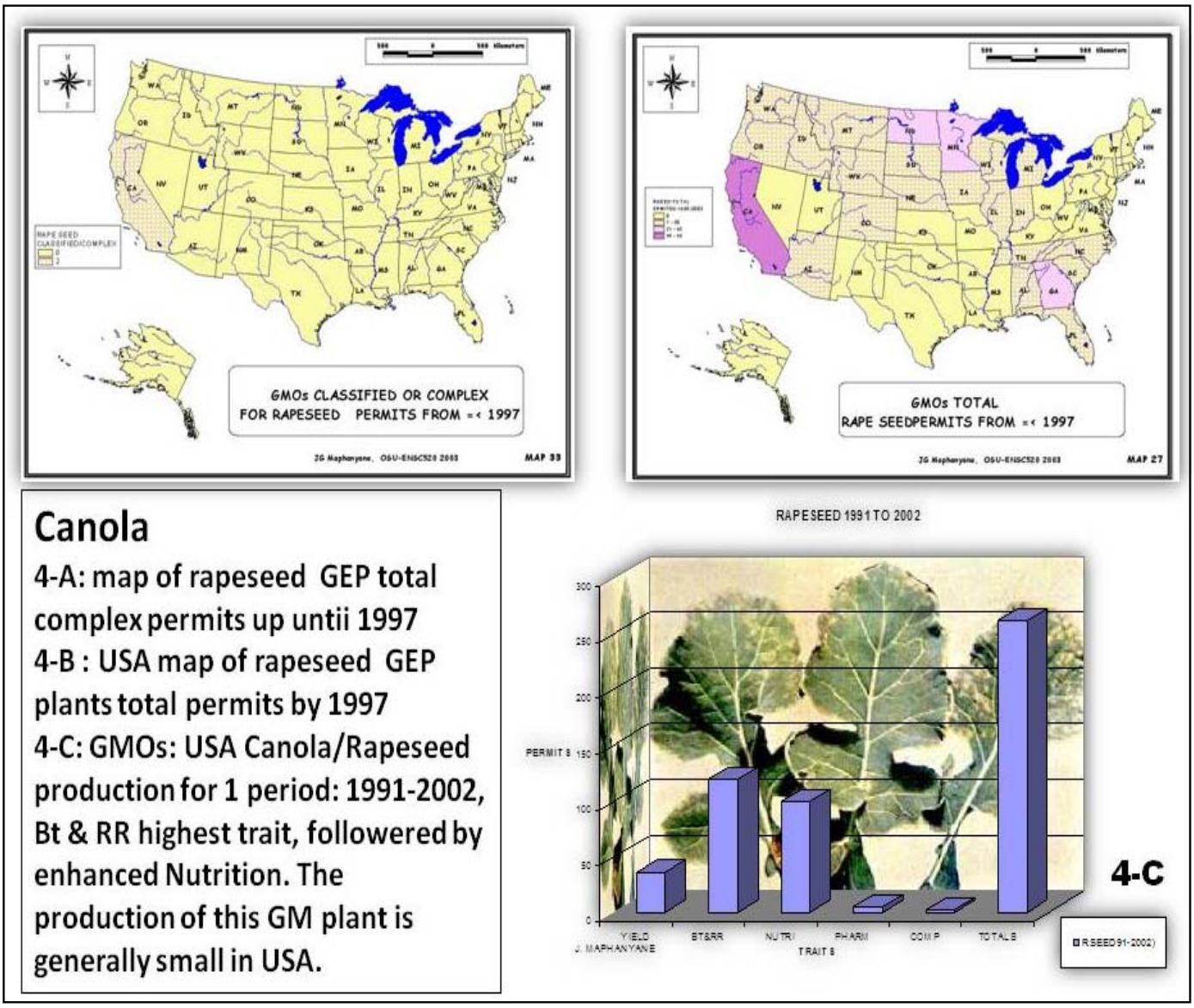

Figure 5. USA Maps of biotechnology permits granted for soybeans planting 4-A before and 4-B after 1987 to 2003 and its rapid development from 1987 to 2003 shown by 4-C One period's graph of 1991-2002.

characteristics of the product, rather than the way in which the production is produced. This USA product-based assessment was the major difference with the philosophy of regulation in the European Union. This process – product difference of philosophy has sparked considerable controversy over recent years.

The USDA-APHIS/EPA regulation of the environmental release was based on the concept of 'familiarity' (Organization for Economic Corporation and Development (OECD), 1993). This concept can be considered the ecological counterpart of the concept of 'substantial equivalence'. Familiarity considers the biology of the plant species, the trait introduced, and the agricultural practices and environment used for crop production. In comparison with a suitable counterpart, often the parental non-GM crop, the aim is to establish if the GM change presents any new or greater risks relative to that counterpart. If an organism has already been evaluated, future assessments of that organism can be less stringent. The application for environmental release are evaluated on a case by case basis and concern weediness, gene transfer, effects on wildlife, altered disease susceptibility and several related aspects of the GM crop (Bonny, 2003).

The GMOs main: reactors and their concerns

The reactors in the GMOs are Europe, Africa and Asia.

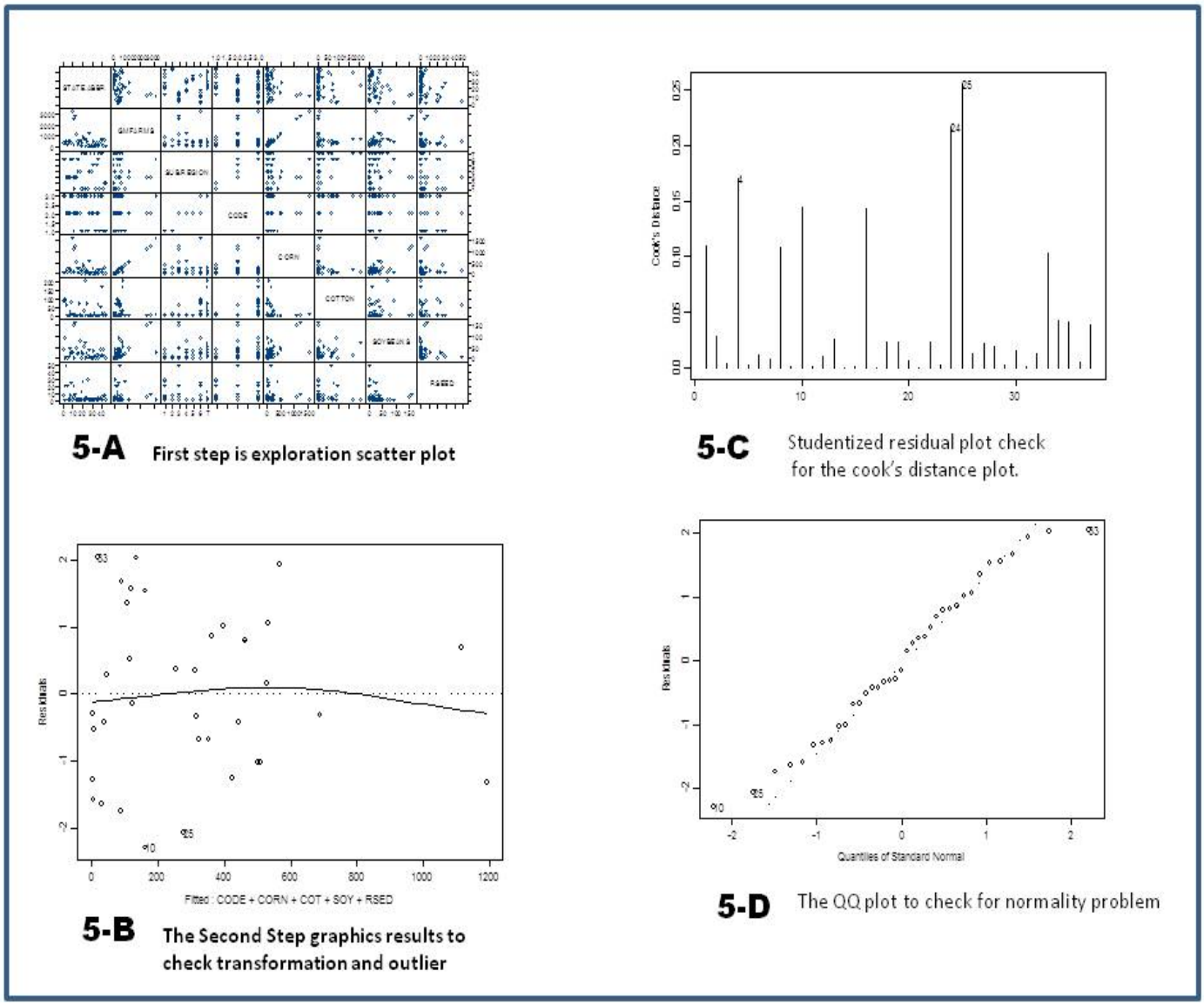

Figure 6. Statistical analysis to establish whether GFP crops of cotton, rapeseed, and cotton, are still grown in areas designated by the Native Americans who the primitive methods and followed the natural climatic conditions.

Western Europe had initially embraced the GMOs, but out of shire pressure from its public and pressure groups they had to suspend the issuing of new permits until their regulatory measures are in place.

EU on regulations, laws, security and insecurity

For Western Europe, the GM crop industry was regulated by several regulations, directives and amendments thereof, which are assembled in a time-consuming and highly complex interplay between the European Commission (EC), the European Parliament (EP), and relevant Council of Ministers and the individual Member States.

The EU regulations considered GM as something new and special for which existing legislation was not sufficient. The EU regulatory system was process based rather than product based. The way soothing was made determines the regulatory framework. This was thought to contribute to better acceptance of genetic modification, notably in the food sector. It was also attributed to heightened awareness and concern in Europe compared to the North American continent. The major philosophy behind the EU regulation Directive 2001/18/EC was its explicit adaptation of precautionary principle as a guide, rather than or in addition to concepts of familiarity and substantial equivalence (The European Parliament and the Council of the European Union, 2001). This was motivated by the United Nations Cartagena protocol on Biosafety. The EU

required very extensive information, with respect to the GMOs molecular characterisation, monitoring and traceability. Since June 1999, *a de facto* moratorium on commercial licensing of new GM products had been in place in the EU. Six EU member Countries, Austria, Denmark, France, Greece, Italy and Luxembourg, decided that they would not accept any new GM approvals at least until a revision of Directive 90/220/EEC was in place.

At the same time, trans-boundary transport GM material across the EU was being established in accordance with international obligations in the Cartagena protocol on Biosafety.

Africa

The entire African continent (African Centre for Biosafety, 2012) was against the GMOs except South Africa. Most of them have signed Cartagena Protocol on Biosafety to the Convention on Biological Diversity (the United Nations Conference on Environment and Development (UNCED), 29 January, 2000). Their feelings towards the GMOs reached a peak when wide spread media publications reported drought ridden and staving Southern African nations totally refused famine Relief GM based food. With this out right refusal, there was wide spread belief that because Europe had rejected genetically engineered food, Africa which needed it, was under pressure to emulate EU countries. But some augured that this remark was unfair to both the Africans and the European. Their argument was that the African's reactions were based on real appreciation of the possible risks. And that the position of Europe was only helping them to argue against surreptitious introduction without going through the due process. It could be proved that European view was only helping Africa to be heard more in its legitimate realisation of the risks, which predated Europe's'. In 1995 for instance, when the positions on the Cartagena Protocol started, Africa took the position to examine genetic engineering and the risks and it developed a draft that was satisfactory for its production. This was submitted in 1996 and it had been the basis of African position. Africa had taken its position long before Europe took its movement to keep out GM crops and therefore it was totally unfair to say that African position was influenced by Europe.

Other arguments that the African put forward were that even the USA had a system in place for approving GMOs, why should Africa be expected to bypass the countries' ability to scrutinise and clear varieties, and if the Cartagena Protocol was followed this will be out of order. Africa also needed to do its own environmental impact assessment analysis and only after that it could decide to embrace or to reject the GMOs.

The risks here include those of human health. Americans had been eating the GMOs food for about six years and for Bt Corn they might be utilizing 2% of corn flakes in their diets. But in Africa where corn form the staple food, it makes up 100% of the daily food intake. So the intake of GM food in the US is fairly low. Domestic animals are reported to dislike Corn. In Africa and most developing countries, crop production and animal production are integrated; the animals constitute the basis for crop production and their food is largely crop residues. If this is not good enough for the animals you are losing the animal production component. Also, it has been claimed that GM Bt Corn has been found to cause 80% loss in reproductive ability was very serious in animal production. So, the Africans worry very much about the GMOs impact on their already fragile agricultural system. Also, they worry that the Bt Corn would kill their butterflies and moths and these creatures are vital in pollinating crops.

They also believe that their farmers will loss control of their seed to the mega agribusiness companies which might cost them dearly, it sounded to them like colonization and control all over again. Africa famine is not caused by lack of production of food alone, but by a number of problems. These included lack of roads to take food from one place to the other; lack of storages to safe food for later and of cause the civil wars in many parts of the continent. There was also no prove that the assumption that the GMOs would increase the production.

In the period from 1987 to 2003, South Africa was the only African country, which has embraced the GM crops. It grew cotton mainly, but there are corn products too.

Biotechnology: How safe is genetically modified (GM) food?

The GM foods were relatively new to jump into any conclusions which require observations that could only come out from long-term use. But as they stand, there were obvious or outstanding problems. Some of these problems were as follow:

a) There were fears that allergic traits can find their way into normally non-allergic food plants during gene transfer,
b) Most foods eaten everyday have a history of safe use. Some however, do not and these foods were considered as being unsafe until they were shown to be safe. Genetically, modified (GM) foods fall into this category. Because they were new to the diet in most countries, they were required to undergo a pre-market safety assessment and manufacturers were required to provide comprehensive package of scientific data used in this assessment.

The safety assessment process for GM foods was based on the best international principles provided by the United Nations (UN) though its Food and Agricultural Organization (FAO) (FOA - Economic and Social Development Department, 1995) (the United Nations Conference on Environment and Development (UNCED), 2000) and subsequence ones like Cartagena Protocol on Biosafety, Montreal (United Nations, 2000) Montreal, (29

January 2000), Nairobi (15 to 26 May 2000), New York (5th June 2000 to 4th June 2001. branch and is carried out by food toxicologists, molecular geneticists, biologists and nutritionists (König et al., 2004). Theoretically, these GM foods were examined before they made their way to the dinner tables of the multitudes. In making an assessment, Food and Technology Boards examined the safety of these new food components separately and fully. They were new in the sense that they may not have previously existed in the food. Significant differences in these properties between the GM food and its conventionally produced equivalent were assessed for potential health effects if any, before they were allowed to be sold for human consumption. In addition, other characteristics of the food such as the levels of nutrients and naturally occurring allergens, toxins and anti-nutrients were considered in detail, as these may be affected by the genetic modification (König et al., 2004).

Two major problems and barriers here were as followers:

a) First problem was that manufacturers normally do not disclose all the production information as it was regarded as patent as some of these were regarded as companies' secrets.
b) Second, the rigorous assessment could only be done by countries with regulations in place and also with manpower and scientific know-how to make well informed assessment, otherwise the GM foods are almost impossible to regulate in most countries, especially the developing nations, more so Africa (African Centre for Biosafety, 2012). They relied heavily on outside expertise or even on the manufacturers themselves whose main interests might certainly not the welfare of those poor nations but were on their commodities sales, economic gain and for profit making which were a great disaster, when withstanding the conflicts of interest which could be at play.

DISCUSSION AND CONCLUSIONS

In conclusion, this project had shown that The GIS was a powerful tool that pulled together facts from a wide variety of sources, and then those facts were used to decide how these available resources should be best managed. The techniques allowed a continuous visual observation of GMOs land cover and monitoring of development of GM agricultural practices from 1987 to 2003 of world and that of the USA GMOs states. These were extraordinary tools without, which, this type of analysis and map making would have taken a very long time to be made. The GIS software used was ARCVIEW, by the ESRI, Redland, USA. The GIS LULCC maps have shown where, when and what type of GMOs were planted for world coverage (Figure 1) and effectively for the USA (Figures 2, 3, 4 and 5). In the USA, GMOs are widely grown throughout the country except for the seven states; New Hampshire (NH), Vermont (VT), District of Columbia (DC), Massachusetts (MA), Utah (UT), West Virginia (WV), and Alaska (AK); of which AK is not farmable anyway because of its frizzing climate, while DC might be limited by the fact that it is a City district, but NH, VT, MA, UT and WV are truly organic states and GMOs free States. Also, this country's states had highly embraced the GEP Corn traits, the production of which have increased by almost 275% from 1989 to 1997 to 1998 to 2003 time periods; the production of Bt and RR being the highest trait embraced and corn being the most produced (Figure 3). This is followed by cotton (Figure 4) and soybeans (Figure 2) and canola (Figure 5) being the least produced. The Bt and RR traits came first; followed by the production of Nutrition enhanced traits; then Nutrition corn being the mostly produced, followed by Nutrition soybeans (Figures 2, 3, 4, 5, Tables 2 and 3).

The research recommends that the key to the reduction of risk caused by the GMOs to the environment was for all the countries to develop regulatory measures, which they could observe fully. To this end, there were two schools of thoughts. First, was for the Americans who based GMOs safety on characteristics of the product based. Second, was that for the Europeans, who measured the GMOs by how it was produced. These two ways of handling the GMOs had caused controversy and a rift between the nations of the world. It was clear that the EU was following a more stringent approach while the Americas less so GMO regulatory system was not so rigid

It also stipulates that formulation and management of the GMOs regulation required highly sophisticated techniques, multidisciplinary and highly qualified scientists as well as a sound budget which the poor countries were unable to afford hence they lacked behind in their GMOs development issues. However, the trans-boundaries and the globalisation of the world trade called for the standardization GMOs risk regulations otherwise the countries with strong GMOs laws would be in vain as they could be easily polluted by products from outside. So, all countries needed to work together for the good of all. Also, with the eminent trade globalisation, the Africans fears that the multi agribusiness foreign companies were gearing up to monopolize the world agricultural trade by forcing them to plant GMOs, which would be based on buying seeds from other countries who will be the ones to gain (Table 1). They feel that their priorities were not the GMOs; but were:

a) Needed better roads to transfer the food from where they are grown to other parts,
b) Food storages were needed to save supplies for the future more especially to use in drought years,
c) Even GMOs could be grown with their anticipated high yield, the needs for bigger storage and even much better roads would be needed to carry the supplies to the markets and,
d) When they converted to GMOs, how are their naturally growing seeds safeguarded together with their traditional ecological knowledge,

Table 2. USA, State GMOs information on soybeans, corn, cotton and canola.

STATE_ABBR	GMFARMS	SUB_REGION	CODE	CORN	COTTON	SOYBEANS	RSEED
ID	138	ENCen	1	56	2	1	20
ME	2	ENCen	1	0	1	0	0
MN	872	ENCen	1	405	0	18	26
MT	6	ENCen	1	1	0	0	4
ND	109	ENCen	1	34	1	5	29
OR	38	ENCen	1	18	0	0	2
SD	362	ENCen	1	172	0	8	2
WA	116	ENCen	1	16	0	39	6
WI	569	MidAtl	1	259	14	8	7
WY	5	MidAtl	1	2	0	0	1
CA	469	Mtn	2	146	62	2	49
CO	158	Mtn	2	69	0	0	20
CT	444	Mtn	2	219	0	3	0
DE	400	Mtn	2	155	2	43	0
IA	2515	Mtn	2	1105	0	150	5
IL	2802	Mtn	2	1235	2	160	8
IN	1117	Mtn	2	513	0	45	1
KY	124	N Eng	2	39	0	23	0
MD	528	N Eng	2	179	6	79	0
NE	1191	N Eng	2	559	0	36	1
NJ	46	N Eng	2	18	0	5	0
NV	88	N Eng	2	44	0	0	0
NY	30	Pacific	2	15	0	0	0
OH	508	Pacific	2	221	0	33	0
PA	316	Pacific	2	146	0	12	0
RI	4	SAtl	2	2	0	0	0
AL	313.0058	SAtl	3	28.0029	88	37	7
AR	424	SAtl	3	33	87	92	0
AZ	274	SAtl	3	33	94	0	20
FL	535	SAtl	3	218	26	20	7
GA	352	SAtl	3	60	79	25	24
HI	3242	SAtl	3	1588	7	26	0
KS	502	SAtl	3	235	0	16	0
LA	256	SAtl	3	35	71	22	0
MI	324	WNCen	3	131	0	25	12
MO	688	WNCen	3	263	30	51	0
MS	690	WNCen	3	69	207	69	0
NC	463	WNCen	3	134	74	22	3
NM	22	WNCen	3	6	3	2	0
OK	92	WNCen	3	23	18	5	0
SC	164	WNCen	3	1	68	11	4
TN	465	WNCen	3	138	52	41	3
TX	692	WNCen	3	164	170	12	0
VA	122	WNCen	3	36	11	14	0

e) If that happens, they would forever dependent on the multi-millions companies with the patent to GEPs seeds.

To address those fears by the Africans, this study recommends training and technology transfer. At the same time, to safeguard the natural seeds and the traditional ecological knowledge, the African countries

Table 3. The five types of gm traits studied in four different crops: - soybeans, cotton, corn and rapeseeds-canola.

Yield quality and altered production: Environmental stress as well as quality traits are:
Improved post harvest storage, flavour such as yield increase, fertility altered, development altered and germination increase, drought tolerant, seed quality altered, cold tolerant, altered amino acid composition, protein altered, maturity altered, senescence altered, male sterile or increased stem strength.
Viral resistant (VR), herbicides (HT) and round and ready (RR): Plants that repel specific and targeted insect pests are:
Coleoteran, *Lepidopteran* resistant, *Glyphosate* tolerant plants; herbicides like *Imidazolinone* tolerant, *Phosphinothrin* tolerant, *Isoxazole* tolerant plants.
Nutritional change content are:
Tryptophan level increased, oil profile altered, yield altered, yield increased, *phytote* reduced, starch metabolism altered, lysine level increased, *carbonhydrate* metabolism altered, animal feed quality improved, nitrogen metabolism altered, seed size increased or *fumonisin* degradation; and colour change such as visual marker or *kanamycin* resistant.
Manufacture industrial as well as pharmaceutical/Medicinal compounds as well as renewable are:
Anthocyarin production seed, gene expression altered, pharmaceutical proteins produced, novel protein produced, industrial enzyme production, *recombinase* produced, *transposon*, coloured sectors in leaves, *transposon* inserted, seed colour altered, *anthocyarin* sequestration suppressed.
Others:
This category included both complex mixtures of traits and undisclosed classified details.

need to have repository storage for all their seeds and all the TEK needed to be documented. The African governments needed to do the bio-technology themselves to their own crops so that they do not lose the patent for their countries' seeds. There had been great upheavals, when the Southern African countries totally refused famine relief GM foods by the USA. It shows how controversial the GMOs can be (African Centre for Biosafety, 2012). Also, another controversy was that, the USA threatened the EU with court case for barring all trade in GMOs.

Another controversy was the Asian countries refusing to accept yellow rice, which was meant to alleviate widespread protein deficiency in those countries. The Asian countries trended with care, as most of them had embraced non-eatable GMOs like cotton, only the Philippines had stated growing GM corn; and all of them have totally rejected the yellow rice. As far as regulatory measures are concerned and the scientific know how, Asia is far ahead of Africa. After all, China has been the first country to grow it commercially, the GM tobacco in 1992 and India now is regarded as being the giant of GM cotton producer. The problems, faced by GMOs producers were loss of trade as many countries opted to be GM free zones, especially in the food sector, as these controversial issues were raised and the majority of ordinary citizens in most countries pushed for no GMOs through pressure groups. In this issue, this research recommended rigorous sensitization of benefits of the GMOs to all stakeholders.

The GMOs on the ecosystem and the biodiversity issues also caused concern. The major causes of concerns include the following:

a) The risks that might be caused by the GMOs on the cross pollination with their weed relatives;

b) Also the unintentional killing of friendly insects like moths; and

c) The unintentional mixture of animal feeds and human food is also being a major concern.

So, to that end, this study recommends care when making the regulations to be inclusive and rigorous policing to see that all regulations have to be followed to the letter. Also, pharmaceutical GMOs were the most sensitive, so, the study recommends that a lot of work and stringent regulation were needed to be in place before any country plant or import them as they posed serious health consequences in the long run. This study concurs with the FOA notion that all in all biotechnology had the potential to have a huge impact on all communities worldwide. Its applications were expected to extend to a number of areas which are important in everyday lives, such as health, medicine, food and agriculture. And that as with any new technology, biotechnology and gene technology had potential risks as well as benefits. And for that reason, a comprehensive regulatory system for each country was essential to regulate the use of biotechnology and gene technology before its adaptation (FOA - Economic and

Table 4. Third step in the statistical procedures - the Extra Sum of Squares to see if when the influential variable has been removed there was still any significance, first checked was whether the interactive model was significant.

STATE_ABBR	GMFARMS	SUB_REGION	CODE	CORN	COTTON	SOYBEANS	RSEED
ID	138	ENCen	1	56	2	1	20
ME	2	ENCen	1	0	1	0	0
MN	872	ENCen	1	405	0	18	26
MT	6	ENCen	1	1	0	0	4
ND	109	ENCen	1	34	1	5	29
OR	38	ENCen	1	18	0	0	2
SD	362	ENCen	1	172	0	8	2
WA	116	ENCen	1	16	0	39	6
WI	569	MidAtl	1	259	14	8	7
WY	5	MidAtl	1	2	0	0	1
CA	469	Mtn	2	146	62	2	49
CO	158	Mtn	2	69	0	0	20
CT	444	Mtn	2	219	0	3	0
DE	400	Mtn	2	155	2	43	0
IA	2515	Mtn	2	1105	0	150	5
IL	2802	Mtn	2	1235	2	160	8
IN	1117	Mtn	2	513	0	45	1
KY	124	N Eng	2	39	0	23	0
MD	528	N Eng	2	179	6	79	0
NE	1191	N Eng	2	559	0	36	1
NJ	46	N Eng	2	18	0	5	0
NV	88	N Eng	2	44	0	0	0
NY	30	Pacific	2	15	0	0	0
OH	508	Pacific	2	221	0	33	0
PA	316	Pacific	2	146	0	12	0
RI	4	SAtl	2	2	0	0	0
AL	313.0058	SAtl	3	28.0029	88	37	7
AR	424	SAtl	3	33	87	92	0
AZ	274	SAtl	3	33	94	0	20
FL	535	SAtl	3	218	26	20	7
GA	352	SAtl	3	60	79	25	24
HI	3242	SAtl	3	1588	7	26	0
KS	502	SAtl	3	235	0	16	0
LA	256	SAtl	3	35	71	22	0
MI	324	WNCen	3	131	0	25	12
MO	688	WNCen	3	263	30	51	0
MS	690	WNCen	3	69	207	69	0
NC	463	WNCen	3	134	74	22	3
NM	22	WNCen	3	6	3	2	0
OK	92	WNCen	3	23	18	5	0
SC	164	WNCen	3	1	68	11	4
TN	465	WNCen	3	138	52	41	3
TX	692	WNCen	3	164	170	12	0
VA	122	WNCen	3	36	11	14	0

Social Development Department, 1995). Public consultation was an integral part of developing regulatory systems, and also the development of public policy, as it allowed the community and stakeholders involved in an

Table 5. The summary of statistical was created first by checking overall significance of the interactive model by FIT FULL MODEL Findings then by FIT REDUCED MODEL findings as shown.

Source of variation	Sum of squares	Df.	Mean square	F-statistics	P-value
Regression	2903871.8	5	580774.36		
Residual	53.6	31	1.729032258		
Total	2903925.4	36			

input into these processes.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

African Centre for Biosafety (2012). GM Food Aid: Africa denied CHOICE once again MAY 08, 2012. From http://www.eraction.org/publications/africa_gm_food_aid[1].pdf.

Bonny S (2003). Why are most Europeans opposed to GMOS? Factors explaining rejection in France and Europe. Electr. J. Biotechnol. 6(1).

Cahn MA (1995). Environmental deceptions: The tension between liberalism and environmental policymaking in the United States. Albany, New York: State University of New York Press.

Donovan D, Puri R (2004). Learning from traditional knowledge of non-timber forest products: Penan Benalui and the autecology of aquilaria in Indonesian Borneo. Ecol. Soc. 9(3):3.

Dunlap RE (2008). The NEP scale: From marginality to Worldwide use. J. Environ. Edu. 40(1):3-18.

FOA-Economic and Social Development Department (1995). World Agriculture: Towards 2015/2030. An FAO study. Retrieved 30/11/2012, 2012, from http://www.fao.org/docrep/004/y3557e/y3557e21.htm#topofpage.

ISAAA (1991). International Service for Agri-Biotech Applications. Retrieved 01/11/2012, 2012, from http://www.isaaa.org/inbrief/default.asp.

ISB (2010). Information Systems for Biotechnology. Retrieved 01/11/2012, 2012, from http://www.isb.vt.edu/data.aspx.

Kilbourne WE, Polonsky MJ (2005). Environmental attitudes and their relation to the dominant social paradigm, among University students in New Zealand and Australia. Austr. Mark. J. 3(2).

König A, Cockburn A, Crevel RWR, Debruyne E, Grafstroem R, Hammerling U, Kimber I, KnudsenI, Kuiper HA, Peijnenburg AACM, Penninks AH, Poulsen M, Schauzu M, Wal JM (2004). Safety assessment, detection and traceability, and societal aspects of genetically modified foods European network on safety assessment of genetically modified food crops (ENTRANS FOOD). Food Chem. Toxicol. 42(7):1047-1088.

Nap J-P, Metz PLJ, Escaler M, Conner AJ (2003). The release of genetically modified crops into the environment -Part I. Overview of current status and regulations. Plant J. 33:1-18.

Organization for Economic Corporation and Development (OECD) (1993). Safety and evaluation of foods derived by modern biotechnology concepts and principles. Paris, France: OECD.

The European Parliament and the council of the European Union (2001). Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms and repealing Council Directive 90/220/EEC. Off. J. Eur. Commun. 106(1):38.

The United Nations Conference on Environment and Development (UNCED) (29 January 2000). Cartagena Protocol on Biosafety, Montreal, Canada: United Nations.

UN (1972). United Nations Stockholm Conference on Human Environment. Paper presented at the United Nations Stockholm Conference on Human Environment Stockholm.

UN (1992). United Nations Global Conference on Environmental and Development. Paper presented at the Earth Summit, Rio de Janeiro.

UN (2002). Report of the world summit on sustainable development. Paper presented at the world summit on sustainable development, Johannesburg, South Africa 26 August to 4th September, 2002.

UN (2007). United Nation Climate Change Conference. Paper presented at the United Nation Earth Summit on Climate Change Conference, held in Bali-Indonesia

UNCED (1992). United Nations Conference on Environment and Development (UNCED), Paper presented at the Earth Summit, Rio De Janeiro, Brazil 3-14 June 1992.

UNEP (1995). International technical guidelines for safety in Biotechnology. Nairobi, Kenya: UNEP.

UNEP-GEF (2004). CZECH Republic final draft National Biosafety Framework as at completion of project. Geneva, Switzerland.

UNFCCC (2009). Report of the conference of the parties on its thirteenth session, held in Bali from 3 to 15 December 2007. Part one: Proceedings paper presented at the United Nation Earth summit on climate change conference, Bali-Indonesia.

Van DeVeer D, Pierce C (1994). The environmental ethics and policy book: philosophy, ecology, economics. Belmont, Califonia: Wadsworth Publishing Company.

Vaughn J (2012). Environmental politics: Domestic and global dimensions (6th ed). New York, NY: Tom Doherty Associates, LLC.

Vig NJ, Kraft ME (2010). Environmental Policy: New Directions for the twenty-first Century (7 ed.). Washington, DC: CQ Press, Sage.

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Saving patterns of rural households in east hararghe zone of Oromia National Regional State, Ethiopia

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This study examined the patterns of rural household savings in East Hararghe zone of Oromia National Regional State in Ethiopia. The major objective of the study was to assess the patterns and its determinants of household savings in the study area. Data were collected from a total of 700 sample households which were also analyzed using descriptive statistics and multinomial logit model. The result of the study signified that 38.5, 23.4, and 38.1% of the sample households have saved in physical assets only, financial form only, and both in physical assets and financial forms, respectively. The result from the econometric model used indicated that, credit access, contact with development agents, leadership role of household heads in the community, information access and membership in microfinance institutions have a significant impact on savings in financial forms only. Whereas, livestock holdings of household in TLU, annual farm income in Birr and leadership role of household heads in the community have a significant effect on the choice of both financial savings and physical saving forms, as compared to saving in physical form only. This study indicated that, the rural households in the study area mainly use the physical forms for savings. However, this savings in physical forms in the study area was not accessed by the formal financial system of the country. Therefore, the study recommends the physical savings of the rural households should be accessed and encouraged to augment gross domestic saving of the country.

Key words: Saving patterns, household savings, east hararghe zone, oromia, Ethiopia.

INTRODUCTION

It is evident that, saving is an important variable at national, private and household levels in contributing for economic growth (Schultz, 2005; Nga, 2007). However, low saving has been a dominant feature of many developing countries (Deaton, 2005; Zhu, 2004). In Ethiopia, the average share of gross domestic savings during the year of 1980 to 2012 was 12.4% of GDP creating the average resource gap of 6.1% during these years (EIA, 2010).

Rural households in Ethiopia in general and the study

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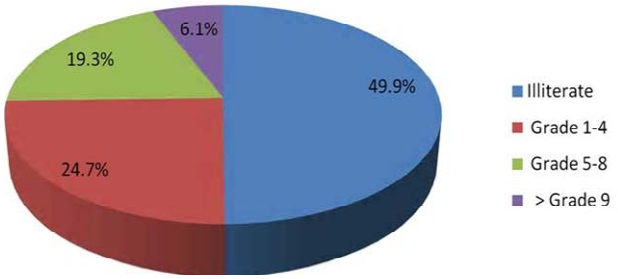

Figure 1. Education level of household head, Source: Own computation from survey data.

area in particular, however, do indeed save in the form of tangible assets and/or in financial forms (Nwachukwu and Odigie, 2009; Kidane, 2010). Some of the major motivations for these households to save include the desire to build up a reserve against unforeseen contingencies, providing for anticipated future differences between income and expenditure, concerns leaving money to heirs and pure miserliness (Canova et al., 2005; Rehman et al., 2010). Rural households usually save in kind when prices are continually rising, when there is little cash in circulation or/and when there is no bank around (Bereket, 2006). The disadvantages of in kind savings are that, they tend to be less portable, more difficult to store and less easily converted into cash (Dejene, 2003; Nwachukwu and Odigie, 2009). According to Beverly et al. (2003) households also saves in cash with the advantages that, cash is very portable, storable and exchanged for almost anything. However, this king of saving form has the problem of losing its value during high inflation (Degu, 2007; Hussien et al., 2007; Nwachukwu and Odigie, 2009). Even though, saving is an important variable that can enhance the productive capacity of the households, very few studies (Abu, 2004; Degu, 2007; Kidane, 2010) have been conducted to assess household saving behavior in Ethiopia. Even, none of these studies have addressed the saving patterns of households in rural areas of the country.

Thus, this study helps to clearly and understands the factors affecting rural household's patterns of savings in the study area. It gives an important input to the country in general and the study area in particular in strategizing and decision making processes of promoting domestic savings at household level to fuel sustainable economic growth. The study also contributes to the few existing studies in developing countries in general and in Ethiopia in particular that gives insight to researchers and can be used as a stepping stone for further similar researches.

MATERIALS AND METHODS

The study was conducted to assess the pattern and the determination of rural household savings in East Hararghe zone of Oromia National regional state in Ethiopia (Table 2). East Hararghe zone is geographically located between 7032' to 9044' North latitude and 410 10' to 43016' East longitudes (Figure 1) (FEDB, 2010). Based on the 2007 Census, the Zone has a total population of 3,039,680 with population density of 151.87 persons per km^2 and with an average of 5 persons per household. Of the total population of the zone 87.4, 12.6, and 1.11% are residents of urban, rural and pastoralists, respectively.

Based on a multistage sampling technique and probability proportional to size (PPS)1 random sampling technique, a sample of 700 households was used for the study. The sample size was determined using the simplified formula developed by Yamane (1967) at 95% confidence level, 0.5 degree of variability and 95% level of precision (Equation 1).

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

Where n is the sample size, N is the total household heads size, and *e* is the level of precision.

Descriptive statistics were used to describe, compare, and contrast various data collected from the households. Multinomial Logistic Regression Model was fitted to estimate the effects of hypothesized explanatory variables on the degree of households' choice of saving patterns (Equations 2 and 3). According to Gujarati (2007), let X be a 1 x K vector with first element unity, then the model has response probabilities of:

$$\Pr(y_i = j) = \frac{\exp(X_i \beta_j)}{1 + \sum_{j=1}^{J} \exp(X_i \beta_j)} \quad (2)$$

and to ensure identifiability;

$$\Pr(y_i = 0) = \frac{1}{1 + \sum_{j=1}^{J} \exp(X_i \beta_j)} \quad (3)$$

Where; for the i^{th} household, y_i is household saving patterns which are savings in kinds only, savings in financial forms only and savings in both kinds and financial forms in which savings in kinds only used as the base category: X_i is a vector of explanatory variables: The unknown parameters β_j is *K x 1* vector matrixes which are typically estimated by maximum likelihood estimation methods.

As it is shown on Table 4, a set of 21 variables (15 continuous and 6 discrete) were included in the model for analysis after all variables were tested for multicollinearity and heteroscedasticity problem. All options of household saving patterns were also tested using Hausman test to check for independence of irrelevant alternatives (IIA).

RESULTS AND DISCUSSION

Here in this study, demographic characteristics and saving patterns of households were discussed using

[1]The PPS is used to determine proportional allocation under which the sizes of the samples from the different cluster are kept proportional to the sizes of the cluster (Kothari, 2004)

Table 1. Age, sex and family size of households.

Parameter	Age of household head in years			Family size in AE			Sex of household head	
	15-33	34-64	>65	< 3.5	3.5-5.5	>5.5	Male	Female
Number of household head	251	359	90	65	299	336	679	21
Total (700 %)	35.9	51.2	12.9	9.3	42.7	48.0	97.0	3.0
	Mean = 38.8, St. Dev. = 11.5 Min = 19 Max = 80			Mean = 6.47, St. Dev. = 2.322 Min = 1 Max =13				

Source: Own computation from survey data.

descriptive statistics. In addition to the descriptive statistics, the result of the econometric model is also discussed here.

Demographic characteristics of households

Age, sex, and family size of households

The survey results (Table 1) show that, the average age of household heads was 38.8 years with the minimum and maximum ages of 19 and 80 years, respectively and standard deviation of 11.5 years. Out of the total 700 interviewed households 251 (35.9%) were in the range of age between 15 to 33 years, 359 (51.2%) were in the range of age between 34 to 64 years and the remaining 90 (12.9%) were in the range of age greater than 65 years. On the other hand, the average family size of the sample households was 6.47 which were higher than the national average of 5 persons (CSA, 2007). The largest family size was 13 and the smallest was 1 with standard deviation of 2.32.

In this study, among the total sampled household heads 678 (97.0 %) were male and the rest 21 (3.0%) were female (Table 1). Of the total sampled household heads, 678 (96.9%), 7 (1.0%), 5 (0.7%) and 10 (1.4%) were married, single, divorced and widowed respectively. About 12.1% (70 male household heads) of the married sample household heads practice polygamy (two wives); while the remaining 96 percent were married to one spouse.

Educational level of household head

Educational background of sampled household heads is believed to be an important feature that determines the ability and willingness of the household head to save and invest. The result shows that, the educational status of households in the study area was considerably low. Most of these household heads had no formal education and are illiterate. From the total sample household heads 349 (49.9%) of the household heads were illiterate, that is, they do not have both writing and reading ability either in their mother tongue or in any other languages. Whereas, 173 (24.7%) have completed grade 1 to 4 level of formal schooling or can read and write. The remaining 135 (19.3%), and 43 (6.1%) attended formal education from grade 5 to 8 primary education and secondary school (grade 9 and above), respectively in which they might be dropped at each levels. The average educational attainment of household head was less than three years with the maximum diploma level education (10 + 2) and 0 year minimum of schooling with standard education of 3.4 (Figure 1).

Saving patterns of households

The survey results revealed that 79.2% of the sampled farm households practiced saving and the rest not with Birr 11365.30 average savings with Birr 1990.50 of standard deviation. The lowest saving level among the savers was Birr 100 and the highest was Birr 236000.

The pattern of disposition of saving is an important factor in determining whether the saved amount is utilized for productive purposes or not. This study has made an analysis of the pattern of savings of the households into financial and physical assets, in general. In Table 3, it is shown that, 38.5, 23.4, and 38.1% of the sample households of those who have saved in physical assets only, financial form, and both in physical assets and financial forms, respectively. Saving in physical assets mainly consists of livestock purchase, grain storage, and others in the study area. The proportion of household saving in financial assets determines the transfer of savings into investment in other sectors of the economy. The volume of saving in physical assets determines the productivity and generation of income in that sector itself.

As it is shown in Table 3, the sample households

Table 2. Patterns of household savings.

S/N	Forms of savings	Frequency	Percent
1	Physical savings only	214	38.5
2	Financial savings only	130	23.4
3	Both physical and financial savings	212	38.1
	Total	556	100
Savings in Birr: Mean 11365.3 Std. Deviation 1990.5 Minimum 0 Maximum 236000			

Source: Own computation from survey data.

Table 3. Reasons for keeping different agricultural products

Reason	Crop products (%)	Livestock products (%)
High price expectation	29.7	72.5
Lack of demand	1.0	3
Saving purpose	63.6	23
Other	5.7	1.5

Source: Own computation from survey data

reported that, about 23.0% of livestock products and 63.6% of crop producing sample farmers avoided sales of their product immediately after harvest for saving purpose. The average storage time of sorghum and maize, the major crop produces in the study area, was3.5 and 5.6 months, respectively.

Econometric model result and discussion of significant variables

As it is discussed earlier, multinomial logit is used to show the determinant variables for each category (savings in financial forms and savings in both financial and kind forms) versus the base category (savings in kind only).

From the model outputs presented on Table 4, the likelihood ratio test statistics exceeds the chi square critical value of 89.6 at less than 1% level of significance, indicating that the hypothesis that, all coefficients except the intercept are equal to zero is rejected that validated that the model fits the data well for this section of the study.

All hypothesized explanatory variables were checked for multicollinearity and heteroscedasticity data problems. The Hausman test results also indicated that, the acceptance of the null hypothesis of independence of the saving forms under consideration as the application of the multinomial logistic regression specification to model was justified ($p = 0.213$).

After Multinomial Logit model estimation, marginal effect of explanatory variables was calculated to see the impact of each explanatory variable on saving patterns of households and the result is presented in Table 5.

Education level of household head

In line with expectation, household head education level was found to have positively significant relation to the choice of saving in kind and financial form as a saving form at 5% probability level (Table 4). *Ceteris paribus*, one extra education level of household head relative to the base category increases the likelihood of the use of savings in both in-kind and financial form increase by 1.1% (Table 5). The positive relation might be due to education can help household heads to decide to use many saving forms at the same time and to involve in available alternative activities to generate more income. This finding is contrary to the findings of Rehman et al., 2010.

Livestock holdings of households in TLU

As expected, livestock holdings of household in TLU were found to have positive and significant (at 5% probability level) influence on the choice of savings both in kind and financial forms as a saving form (Table 4). Given all other variables constant, the likelihood of household head's choice of both in kind and financial saving form relative to the base strategy (in kind saving only) increases by 4.86% when TLU increase by one unit (Table 5).

This implies that household with more livestock holdings would like to save in both financial forms and in kinds. This finding is similar with that of Degu (2005) but not similar with the findings by Obayelu (2012) that shows a negative relationship between financial savings and livestock holdings of rural households.

Table 4. Parameter estimates of the multinomial logit for patterns of household savings

Variable	Financial Saving only				Saving in kind and financial forms			
	Coef.	Robust Std. Error	z	P>|z|	Coef.	Robust Std. Error	z	P>|z|
Age of household head	0.0025675	0.0125573	0.20	0.838	0.0062956	0.0115677	0.54	0.586
Sex of household head *	0.1874724	0.5997699	0.31	0.755	0.1074998	0.7175693	0.15	0.881
Household head education level	0.0380841	0.0390735	0.97	0.330	0.0642625**	0.0348289	1.85	0.045
Household size in AE	-0.0702926	0.0653019	-1.08	0.282	-0.0484418	0.0554937	-0.87	0.383
Dependency ratio	-0.0289937	0.1580245	-0.18	0.854	-0.1951532	0.1612004	-1.21	0.226
Annual household investment in Birr	8.31e-06	0.0000131	0.64	0.525	0.0000137	0.0000123	1.11	0.265
Land holdings in ha	-0.0412524	0.0372404	-1.11	0.268	0.0620527	0.0480857	1.29	0.197
Livestock holdings in TLU	0.0171411	0.0966979	0.18	0.859	0.2281329**	0.0888387	2.57	0.010
Annual farm income in Birr	0.0000174	0.0000108	1.62	0.106	0.0000276**	9.48e-06	2.92	0.004
Annual nonfarm income in Birr	0.000044	0.0000375	1.17	0.240	0.0000527	0.0000378	1.39	0.164
Credit access *	-0.880353***	0.2639512	-3.34	0.001	0.0807509	0.2526188	0.32	0.749
Distance from financial institutions in km	-0.0224777	0.0296192	-0.76	0.448	0.0068508	0.027026	0.25	0.800
Distance from market center in km	-0.00031	0.0288163	0.01	0.991	0.0144458	0.0286286	0.50	0.614
Distance from all weather road in km	-0.0071841	0.0176329	-0.41	0.684	-0.0092372	0.0194728	-0.47	0.635
Training participation	0.0730112	0.1062034	-0.69	0.492	0.0801049	0.1005948	0.80	0.426
Contacts with DAs	-0.0156876**	0.0075408	-2.08	0.037	0.0054852	0.0064486	0.85	0.395
Leadership role in the society*	0.986194**	0.4000655	2.47	0.014	0.8043724**	0.4263863	1.89	0.049
Information access*	0.6643871***	0.4762724	1.39	0.003	0.6927813	0.4298232	1.61	0.107
Membership in microfinance institution*	1.484554***	0.273561	5.43	0.000	-0.1394401	0.2743923	-0.51	0.611
Income from perennial crops in Birr	0.0000119	0.0000173	0.69	0.493	0.0000212	0.0000162	1.31	0.190
Constant	0.9467256	1.253236	0.76	0.450	-2.450779	1.252526	-1.96	0.050
Savings in kinds only (base outcome), Number of obs = 540, Wald chi2(42) = 137.51, Prob > chi2= 0.0000 Log pseudolikelihood = -502.29899, Pseudo R2 = 0.1376								

Source: Own computation from survey data.

Annual farm income in Birr

Annual income from farm activities of sample households had positive and significant (at 5% probability level) impact on the probability of using *savings* in kind and financial forms option (Table 4). As compared to in kind savings only (the base category), an increase in farm income by one Birr increases the probabilities of the use of savings both in kind and financial form option by 0.0004%, *ceteris paribus* (Table 5). Part of the explanation for this king of result is farm income would increase household's saving ability and enhance the probability of household to save in different forms. This is consistent with studies by Adeyemo and Bamire (2005), and Rehman et al. (2010).

Credit access of household

As expected, credit access of the household member was found to influence financial saving option of households' saving forms negatively and significantly at 1% probability level (Table 4). This result indicates that households with access to credit less prefer financial saving form to in-kind saving as compared to households without credit access. Keeping other factors constant in the model, as compared to in kind savings (the base category) the likelihood of households with access to credit to chose financial saving decreases by 17.6%, when access to credit increases (Table 5). The available credit was mainly used to purchase improved agricultural inputs as lack of capital source for investment in agriculture sector is the bottleneck in the study area. This finding is similar to that of Adeyemo and Bamire (2005) but contrary to the findings of Obayelu (2012).

Contact with development agents

Contrary to hypothesized, contact with development agents was found to be negatively and significantly correlated to the choice decision of financial saving option at 5% probability level (Table 4). This means, keeping other variables in the model constant, when contact with development agents increases by one , the probability of using financial saving options decreases by

Table 5. Marginal effect of explanatory variables on patterns of household savings.

Variable	Financial Saving Pattern only dy/dx	Saving in kind and financial Patterns dy/dx
Age of household head	-0.0000278	0.0011738
Sex of household head *	0.0435848	0.0386449
Household head education level	0.0019296	0.0110259
Household size in AE	-0.0092047	-0.0049672
Dependency ratio	0.0102911	-0.0404531
Annual Household investment in Birr	4.48e-07	2.33e-06
Land holdings in ha	-0.0026979	-0.0102867
Livestock holdings in TLU	-0.0151523	0.0486367
Annual farm income in Birr	1.02e-06	4.66e-06
Annual nonfarm income in Birr	3.97e-06	8.00e-06
Credit access *	0.1760081	0.0900782
Distance from financial institutions in km	-0.0036382	0.0003057
Distance from market center in km	-0.0012195	0.003192
Distance from all weather road in km	-0.000596	-0.0014474
Training participation	0.0200494	0.0234337
Contacts with DAs	-0.0033648	0.0024642
Leadership role in the society*	0.1191088	0.0970365
Information access*	0.062584	0.0932432
Membership in microfinance institutions*	0.2654641	0.0888206
Annual income from perennial crops in Birr	5.13e-07	3.69e-06
y = Pr(Financial only) (predict, outcome (2)) = 0.24775258		
y = Pr(Both in kind and financial forms) (predict, outcome (3)) = 0.32460685		

(*) dy/dx is for discrete change of dummy variable from 0 to 1, source: Own computation from survey data.

0.34% relative to the base category (in kind savings only) (Table 5). One of the reasons could be, development agents are mainly encouraging rural households to use their capital on agricultural development and have little knowhow about financial institutions and savings.

Household head leadership role in the society

In line with expectation, household heads' leadership role in the society was found to have positive and significant influence on both financial saving only and savings in kind and financial forms at 5% probability level (Table 4). *Ceteris paribus*, the likelihood of household heads with leadership role in the society to choose of both financial saving only and savings in kind and financial forms increases by 11.9 and 9.7% in relative to the base category, respectively (Table 5). Households who bear the responsibility to execute and organize on the behalf of the community get the chance to acquire timely and vital information from government officials and change-agents. Thus, household heads with leadership role in the society were better off in financial and in kind savings than the household heads that do not have leadership role in the society. This finding is similar to that of Kifle (2012).

Information access of household head

As expected, access to information was found to have positive and significant (at 1% probability level) to influence on decision to use financial saving (Table 4). Given all other variables in the model held constant, the likelihood of household heads' choice of financial saving relative to the base category increases by 6.3%, when households get access to information (Table 5). This implies that the household head savings in financial forms increases as their access to information increases as it improves their knowledge about the use of financial institutions. This finding is similar to that of Rehman et al. (2010).

Membership in microfinance institution

In line with prior expectation, being a member of MFI influence the choice of financial saving positively and significantly at 1% probability level (Table 4). *Ceteris paribus*, the likelihood of using financial saving option increases by 26.5% for those MFI of member households relative to the benchmark alternative (Table 5). The household who are participating in microfinance activities would have more of in financial forms as compared to

households with no participation in microfinance institution. This implies membership of households in MFI plays a determining role in providing access to formal credit and compulsory savings. This finding is similar with that of Kifle (2012).

CONCLUSIONS AND RECOMMENDATIONS

In this paper an attempt has been made to analyze saving patterns of rural household in East Hararghe Zone of Oromia National Regional state, Ethiopia. The result of the study indicate that, households have different saving patterns namely savings in physical forms and savings in financial forms.

The result of the study also shows that, education and training participation enhance household's awareness to decide to use many saving forms at the same time. Households with more livestock holdings and annual farm income would like to save in both financial forms and in kinds as they increase the saving ability and opportunity of households. Households with access to credit less prefer financial saving form to in-kind saving as the available credit was mainly used to purchase agricultural inputs. Access to information increases household's saving in financial forms as it improves their knowledge about financial institutions.

The study has shown that, households have the capacity to save mainly in nonfinancial forms showing high request for accessibility potential for formal financial institutions. Therefore, the physical saving forms of rural households should be encouraged and needed to be accessed by the financial intermediaries of the country.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Abu G (2004). On the Determinants of Domestic Saving in Ethiopia. Prepared for the Second International Conference on the Ethiopian Economy. Ethiopian Economic Association Retrieved July 17, 2013, from http://www.scribd.com/doc/53352267/Abu-Girma-Determinants-mestic-savings-in-Eth.

Adeyemo R, Bamire AS (2005). Saving and Investment Patterns of Cooperative Farmers in Southwestern Nigeria. J. Soc. Sci. 11(3):183-192.

Bereket K (2006). Land Reform, Distribution of Land and Institutions in Rural Ethiopia: Analysis of Inequality with Dirty Data. School of Development Studies, University of East Anglia and Center for the Study of African Economies, University of Oxford.

Beverly SG, McBride A, Schreiner M (2003). A Framework of Asset-Accumulation Stages and Strategies. J. Fam. Econ. 24(2):143-156.

Canova L, Rattazzi A, Webley P (2005). 'The hierarchical structure of saving motives'. J. Econ. Psychol. 26:21-34. Accessed on August 3, 2013 from http://www.researchgate.net/publication/222838006_The_hierarchical_structure_of_saving_motives/file/32bfe50f84aa9b8b4c.pdf.

Central Statistical Agency (CSA) (2007). Statistical abstract. Addis Ababa, Ethiopia.

Deaton AS (2005). Franco Modigliani and the Life Cycle Theory of Consumption. Banca Nazionale del Lavoro Quarterly Review. [Provide page number(s)]

Degu A (2007). Household Savings Behavior and Determinants of Savings in Rural Savings and Credit Cooperatives in Selected Districts of Western Amhara Region, Ethiopia. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. p. 135.

Dejene A (2003). Informal Financial Institutions: The Economic Importance of Iddir, Iqqub, and Loans, Technological Progress in Ethiopian Agriculture, Proceedings of the National Workshop on Technological Progress in Ethiopian Agriculture. Addis Ababa University, Ethiopia.

EIA (Ethiopian Investment Agency) (2010). Ethiopian Investment Guide, Adiss Abeba, Ethiopia. [Online] Available: http://www.ethiopianembassy.org/PDF/Investment_Guide_2010.pdf [February, 2013].

FEDB (Finance and Economic Development Bureau) of East Hararghe Zone (2010). Physical and Socio - Economic Profile. Harar, Ethiopia.

Gujarati DN (2007). Basic Econometrics. 4th edition. Mc Graw-Hill, Inc., New York.

Hussien H (2007). Farm Household Economic Behaviour in Imperfect Financial Markets: Empirical Evidence and Policy Implications on Saving, Credit and Production Efficiency in Southeastern Ethiopia. A Doctoral Thesis Presented to the Department of Economics, Swedish University of Agricultural Sciences. Uppsala, Sweden.

Kidane B (2010). Determinants of Gross Domestic Saving in Ethiopia: a Time Series Analysis. StudyMode.com. Retrieved July 17, 2013, from http://www.studymode.com/essays/Determinants-Of-Gross-Domestic-Saving-In-535269.html.

Kifle T (2012). Determinants of saving Behaviour of cooperative members survey evidence from Tigrai region, Ethiopia. Journal of Research in Economics and International Finance (JREIF) 1(5):150-158.

Kothari CR (2004). Research Methodology: Methods and Techniques. 2nd edition. New Age International Publications. Dharmesh Printers, Delhi.

Nga MT (2007). An Investigative Analysis into the Saving Behavior of Poor Households in Developing Countries: With Specific Reference to South Africa. University of the Western Cape, South Africa.

Nwachukwu T, Odigie P (2009). What Drives Private Saving in Nigeria. Centre for the Study of African Economies Conference, University of Oxford.

Obayelu OA (2012). Saving Behavior of Rural Households in Kwara State, Nigeria. Afr. J. Basic. Appl. Sci. 4(4):115-123.

Rehman H, Faridi MZ, Bashir F (2010). Households Saving Behaviour in Pakistan: A Case of Multan District. Pak. J. Soc. Sci. 30(1):17-29.

Schultz TP (2005). Demographic Determinants of Savings: Estimating and Interpreting the Aggregate Association in Asia. Discussion paper series IZA DP Yale University and IZA Bonn. p. 1479.

Yamane T (1967). Statistics, an Introductory Analysis, 2nd Ed., New York: Harper and Row.

Zhu Q (2004). The Impact of Rural Enterprises on Household Savings in China. ZEF – Discussion Papers on Development Policy Bonn, Germany.

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Gender and small-farmer commercialisation: The case of two farming communities in Ghana

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Different options of enhancing household financial status are explored by farmers in Ghana in order to cope with fast changing economic conditions. These include intensification of traditional crop production, diversification into new high value crops and off-farm activities. This paper examines small-farmer commercialisation (SFC) activities in the forest and transition zones of Ghana. Participatory appraisal methods including wealth ranking, livelihood analysis and interview of key informants and opinion leaders were used. The wealth ranking exercise resulted in the identification of three household categories as rich, intermediate and poor. Vegetable production was found to be an important commercialisation activity and pepper production was very successful in one subsidiary village in the forest zone, where the farmers formed a group for production and marketing of the produce. Adopters of SFC are motivated by profitability, regular flow of income from quick maturing crops, and important for women was the desire for financial independence and change in social status. A major barrier to participation in SFC is lack of credit as the adoption is both labour and capital intensive though large land holdings may not be required.

Key words: Women farmers and gender equality, farming systems, wealth ranking, small-scale farmer commercialization, participatory appraisal methods.

INTRODUCTION

The starting point of structural transformation is broad-based smallholder-led agricultural growth and commercialisation, integrating traditional smallholder farmers into the exchange economy (Jayne et al, 2011; Heltberg and Tarp, 2002). Commercialisation of subsistence agriculture in developing countries has led to different levels of production and consumption changes for men and women (Adenegan et al., 2013). The impact of smallholder commercialisation on gender depends on the available resources and on who controls the income generated. According to Berhanu and Jaleta (2010), commercialisation entails market orientation and market participation, and enhances the links between the input and output sides of agricultural markets. Men and women in Ghana are faced with changing roles as a result of the transformation of agricultural enterprises from subsistence-based farming to market-oriented production systems and activities. The efforts of moving from subsistence-based production to more market oriented production is known as small-farmer commercialisation (SFC), the impact of which has not been rigorously ascertained.

Gender equality and the empowerment of women have been on the agenda for global development efforts for

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some time now. Indicators for this goal have focused on enrolment in school and status of women at all levels. Nota lot of attention has been devoted to exploring ways of empowering women in agriculture in general and in rural areas in particular. Fortunately, the impact of gender in improving the livelihoods of rural populations and people engaged in agriculture has recently been the focus of many global and continental institutions (IFAD, 2012; UNDP, 2012; WFP, 2012; FAO, 2011; World Bank, 2011; IFAD and AfDB, 2010). Studies on gender and agricultural commercialisation have focused on impacts of cash cropping on men and women and relations with nutrition and food security (von Braun and Kennedy, 1994; Webb, 1989). Not much work is available on what factors will make women adopt commercialisation activities. Little data exists in Ghana on men and women's agricultural commercialisation activities.

The aim of this paper is to assess the gender impacts of SFC in the forest and transition agro-ecological zones in Ghana, drawing experiences from the savannah zone. Each zone differs in population density, farming systems and livelihood experiences. The study identifies and examines small-farmer commercialisation activities, its pathways and constraints, and the motivation for SFC. It provides information for understanding how intra-household and inter-household gender relationships are affected by small-farmer commercialisation (SFC) in rural communities.

LITERATURE REVIEW

Given the interconnectedness of biological and social dimensions of human behaviour, gender should be seen to encompass both sex differences and social constructs that give rise to differences between men and women (Phillips, 2005). It is the central organizing principle of societies that governs the processes of production and reproduction, consumption and distribution (FAO, 1997). Gender analysis studies the different roles and responsibilities of women and men, the differences in women's and men's access to and control over resources, and their consequent constraints, needs and priorities. Incorporating gender analysis into the tools of participatory agricultural planning helps policy-makers and planners to understand how the structure of policies and programmes need to be designed to ensure that women benefit as well as men. Hunt (2004) added that gender analysis helps assess the impact of development activity on females and males, assess the differences in participation, and accrued benefits between men and women, towards sustainability and gender equality.

Globalization affects farmers around the world in different ways, based on their specific characteristics, the nature of their market networks and cropping patterns. Remoteness of a market reduces supply (Alene et al., 2008), and negatively affects farmer incomes. Market integration of producers of fruits and vegetables has been shown to be higher than that of staple crop producers (Weinberger and Lumpkin, 2007). Inability of local agriculture to provide a reasonable standard of living pushes off farmers into low-paying jobs in towns (Jayne et al., 2011). As such, remaining in subsistence production with little market surplus that is sold in local markets limits the ability of smallholders to be better connected to the rest of the world.

Commercialisation is about increasing engagement with markets, increasing inputs and factors of production acquired from the market, using markets to hire labour, and borrowing funds to rent land, obtain technical advice and market information (Wiggins et al., 2011). It involves production of greater farm surpluses, expansion of participation in markets, and increases in farmer incomes and living standards (Jayne et al., 2011). Commercialisation of agricultural systems leads to greater market orientation of farm production (Pingali and Rosegrant, 1995; von Braun and Kennedy, 1994). Changes in product mix and input uses are determined largely by the market forces during the transition from subsistence production to market-oriented systems.

Smallholder farms are risk averse and do not make changes that could put them at financial risk or compromise their ability to ensure adequate supply of food for their household. Wiggins et al. (2011) noted that most examples of small farmers commercialising do not involve radical changes, but take place within existing farming systems, within existing land tenure systems, and are carried out by households using own labour.

Commercialisation leads to increases in income levels for small farmers. However, some researchers have expressed fears that agricultural commercialisation can weaken the role of women and their control over resources and income (Fischer and Qaim, 2012; Wiggins et al., 2011; Quisumbing et al. 1995; Quisumbing and Meinzen-Dick, 2001). According to Fischer and Qaim (2012), increasing degrees of commercialisation may worsen the role of women within farming households. Commercialisation is a major source of productivity growth in the future, yet, what is essential, as noted by Timmer (1997), is the need to deal with the risky environments facing farmers in order to speed up the commercialisation process.

METHODOLOGY

Study sites

The study was carried out in six rural communities in two important farming system zones in Ghana which represent a cross-section of SFC experiences across the country. Farmers in these areas produce a market surplus and the areas have strong trade links with the rest of the economy. At least some farm households in the area are actively involved in SFC or are in the process of adopting SFC activities. They are the transition zone (a major staple food supply zone in Ghana) and the forest zone (has farming systems that are important in terms of foreign exchange revenue generation for the country). The farming systems that characterize the

Figure 1. Map showing the three selected farming system zones.

transition zone are cereals, root and tubers, cotton, fishing, and livestock and those of the forest zone are tree crops (cocoa and oil palm), root and tuber crops, cereal and livestock.

One principal study village was first selected in each of the two farming systems. These are representative of the selected farming systems and have a growing incidence of commercialisation. They are Offuman for the transition zone and Bekwai for the forest zone. Two secondary villages were then selected in each farming system in the vicinity of the principal study village, which has relatively different production structures and market access. This helps to understand whether the SFC activities were also prevalent in smaller villages. Nyansuaka and Amoamo were the subsidiary villages in the forest zone, and Ampenkro and Adankranja were for the transition zone. The presence of a diversity of SFC activities was considered in the selection of communities.

The forest zone is located in the Ashanti Region of Ghana, in the Amansie East District with Bekwai as the district capital. Bekwai, which is about 40 km from Kumasi, the regional capital of the Ashanti Region, has a vibrant non-farm economy with significant marketing and trading activities. The site falls within the tropical rainforest with hilly topography and bimodal rainfall pattern. The transition zone is located in the Techiman District of the Brong-Ahafo Region of Ghana. It is the area between the forest zone in the south and the savannah zone in the north. Offuman is about 30 km from the district capital, Techiman, which has an international market patronised by traders from other parts of Ghana, and some West African countries including Togo, Burkina Faso, Mali and Cote d'Ivoire. The Techiman market goes on from Tuesday to Friday every week, unlike many markets that have a specific day of the week as market day. The presence of the market, coupled with improved road network to Offuman and to one of the subsidiary villages has resulted in vibrant market activities and trading in the community. Population density of the area is fairly low. A map of the study area showing the farming system zones is presented in Figure 1.

Analytical techniques

Participatory appraisal methods were used for case studies in selected communities in the forest and transition zones of Ghana in order to capture changes that have occurred in their farming systems. Qualitative approaches were used coupled with in-depth interview of key informants to create a good database of the activities of the smallholders. The research methodology draws on rapid appraisal methods including wealth ranking, livelihoods analysis, income and expenditure matrices, benefit analysis flow chart, interview of key informants and opinion leaders, participant observation, and a review of secondary data. The combination of approaches helps to capture as much of the commercialisation activities in the communities as possible and reveal the challenges and barriers that limit their adoption of SFC.

Village entry approaches were used to prepare the communities ahead of actual visits for data collection. Community meetings were held in each of the principal and subsidiary villages, which were well attended by several households. Attendance at the community meetings in the selected villages ranged between 13 and 48 participants with female participation averaging about 40 percent of the total number. Women participated actively and were very outspoken in the two principal villages and Adankranja in the forest zone than in the other villages. It was observed that female participation improved whenever encouraged and also when the women were grouped separate from the men. Several days were spent holding meetings in each village.

The criteria for household classification were identified together with the community members for the wealth ranking exercise as no prior criteria for the classification was predetermined. Participants were given 100 cards to distribute according to wealth categories within the village. The criteria identified for household classification are farm size, asset ownership, livestock ownership, ability to educate children, type of housing, and adoption of improved production methods. Participants were also grouped by gender for income and expenditure matrix analysis.

For the income and expenditure analysis, the participants were divided into two groups based on gender and each group was given cards representing a specific amount of money, and was asked to distribute them among their main sources of income and expenditure. This exercise gave a clear indication of the patterns of expenditure of men and women as well as their income sources. The income generating activities were identified and documented in

each village. The livelihood activities were characterised to identify areas and pathways of commercialisation. Some of the information was obtained from key informants such as relevant officials at the District Agricultural Development Unit (DADU), the District Assemblies and village leaders.

RESULTS AND DISCUSSION

Household characteristics by wealth

The wealth ranking exercise revealed three main wealth categories namely; those who are rich, those who are intermediate and those who are poor. These categories in the Akan language, which is widely spoken in the forest and transition zones of Ghana, are '*osikani'* for rich, and '*dantemni'* and '*ohiani'* for intermediate and poor respectively. The household categories by wealth are similar in all the study communities. In the forest zone, the rich constituted 8% of the total households in the community, the intermediate households were 55% and poor households were 37%. In the transition zone, while only 5 percent are in the rich category, 71 percent of households are in the intermediate category and 24% are poor. Results from the household interviews show that the proportion of the households who are within the rich category ranges from 2% to 8% in the study areas, which is consistent with the finding from the focus group discussions. Majority of farmers are classified under the *'dantemni'* (intermediate) category. Targeting development programmes at the intermediate and poor households can yield the best results for farmers in rural communities.

The wealth ranking exercise in Offuman, the principal village of the transition zone, showed that the rich had larger household size (more people living in the household) than the poor and the intermediate categories. Most of the households in the rich and intermediate categories have built their own houses but only 40 percent of the poor live in their own houses. The rich live in cement houses which are roofed with iron sheets. About 65% of those in the intermediate group have cement houses and 35% have brick houses roofed with iron sheets. All those who are considered as poor are in mud houses; 30% with thatch roofing and 70% had iron sheet roofing. Household size is not different in the forest zone, where the average household size is larger for rich households than for poorer households. According to the farmers, though there are very rich people who are part of their communities, they have migrated to live elsewhere. The rich and intermediate categories contribute significantly towards community development projects.

Farm size is related to wealth status. Average size of cultivated land is 170 hectares for rich households and 2 hectares for poor households. Production levels are also proportional to wealth status. Households with very small farm sizes are often food insecure as they also have low incomes and limited range of economic activities. While the rich farmers are more diversified in both agricultural and non-agricultural activities, poorer households have farming as their only occupation and means of livelihood. Besides, richer households are able to adopt new technologies faster than poorer households.

The rich have more resources, are more educated, and have skills that enable them to produce on a large scale. There are differences in the level of education of household members among the categories. The poor and intermediate households are less educated, have limited skills, depend on traders who come to the village to sell their farm produce, and are often compelled to sell their produce early. The rich are able to move their produce to markets outside their local community to sell at competitive prices, with some engaged in trading and buying of farm produce from other farmers to sell in markets outside the village. The rich tend to have stronger market linkages and access to a wider range of information. To cope with livelihood difficulties, the poor resort to providing labour services on other farms for daily wage in order to provide food, pay school fees for children and meet other household needs.

Farming systems and small-farmer commercialisation activities

African smallholders have diverse sources of livelihood including crop and livestock farming and off-farm activities. In farming communities, commercialisation encompasses selling of a marketable surplus of traditional crops, diversification into the production of new crops, introduction of new income generating activities and post-harvest activities such as processing of farm produce. Livestock sales are undertaken in limited communities in the transition zone. Beyond keeping of few animals for household consumption, livestock production is not widespread in the forest zone. Different communities were found to have different production structures, potential for economic growth and value-added systems. Produce from food crops were consumed within the household and the surplus was sold for income. Where household members are engaged in non-farm activities or diversified agricultural production activities, they are able to finance the production of new crops and store farm produce to sell at a higher price at a later date.

Commercial production of vegetables (garden-eggs, tomatoes and pepper) was the most important pathway to commercialisation in the 6 villages visited (Table 1). Overall, about 31 percent of all cultivated land is devoted to vegetable production in the study area and 35 percent was to the production of root and tubers. Rich households can cultivate about 10 acres of vegetables while the intermediate households can cultivate about 5 acres of vegetables. Vegetable production was very

Table 1. Commercialisation pathways in two agroecological zones in Ghana.

Forest zone		
Asanso	**Adankranja**	**Denyasi**
Crops: Vegetables. Brought to village a few years ago from the Brong-Ahafo Region (Transition Zone). ***Non-agriculture:*** Trading in district and regional capital. Artisan work.	***Crops:*** Vegetables (pepper). Taro, cocoa, oil palm are also lucrative but limited to few people and few areas. ***Non-agriculture:*** Widespread small-scale trading in agricultural and non-agricultural products.	***Crops:*** Vegetables. Intensification of cocoa production. ***Non-agriculture:*** Trading
Transition zone		
Offuman	**Nyansuaka**	**Ampenkro**
Crops: Vegetables (tomatoes and garden-eggs). ***Non-agriculture:*** Trading in agricultural produce and ownership of stores ***Other:*** Keeping of livestock.	***Crops:*** Vegetables (very limited). Grows a lot of maize ***Other:*** Keeping of livestock	***Crops:*** Vegetables (tomatoes). Tomatoes processing factory being rehabilitated in a nearby town. ***Non-agriculture:*** Limited trading.

effective where the producers have formed a group for production and marketing. Only small amounts of vegetables are consumed at farm household level. Households consume a lot of cassava, plantain, maize and taro. Cocoa, oil palm and citrus are cultivated, but in limited quantities. As such, vegetables should be considered as cash crop.

Pepper production is very successful in Adankranja in the forest zone. A community member bought the seeds and began its production in 1983, a period when Ghana experienced extreme hardship and famine. After the first cultivation, he introduced four of his friends to it and all the four friends became wealthy through pepper cultivation. In the principal village, vegetable production was introduced from the transition zone (Brong–Ahafo Region). In these villages, the 1983 famine in Ghana led to a shift in the production of tree crops to the production of pepper in order to get quick money. Pepper production then expanded over the years.

The pepper farmers in Adankranja formed a group that had a membership of about 30 farmers. The cooperative enabled them obtain credit, which they paid up promptly. They were also able to access loans from the market women who bought the pepper. As a group, they negotiated for good and stable prices for their produce and agreed on a harvesting pattern whereby only a specific number of farmers harvested pepper at a time, to regulate the quantity available on the market at a given time.

The use of fertilizers and agro-chemicals started in 1988 due to low soil fertility and the incidence of pests and diseases. In the same year, the pepper farmers' cooperative bought a water pumping machine, which helped with dry season cultivation. Pepper cultivation gradually changed from small-scale farming to large-scale cultivation and new varieties were introduced with time. However, the withdrawal of government subsidies which were on agricultural inputs through the Economic Recovery Programme (ERP) and Structural Adjustment Programme (SAP) resulted in very high cost of inputs and presents a constraint for adopting SFC.

Another example of SFC is maize. Farmers in Nyansuaka, a subsidiary village in the transition zone cultivate a lot of maize for sale. The driving force behind the cultivation of maize is its storability and contribution to household food security. It is consumed in large quantities throughout the year. Maize can be stored for a long time and sold during the lean season at a higher price. There is a high motivation for growing more maize as vegetables are perishable but are not processed. The farmers have constructed a maize storage unit where they store maize in bulk. Maize can be planted twice in a year and also brings quick income to farm households, and turns out to be the most profitable staple crop if it can be cultivated on a large scale and stored for a long period of time.

Ability to store storable farm produce makes it possible for farmers to sell them at a time when the price is favourable and when farmers are in need of money. Farmers who do not have money to pay off debts after the cropping season are compelled to sell their produce early. Rich households are more capable of storing farm produce than the intermediate and poor households. Obviously, the poor are compelled to sell immediately after harvest at prices that are usually dictated by the buyers. The farmers indicated that financial pressure, lack of alternative income generating activities and non-farm employment opportunities compel them to sell their produce early, which has implications for food security, investment and other financial obligations.

In addition to farming, there were a few off-season and non-farm activities such as firewood gathering, charcoal

production and general trading, including moving of farm produce to sell outside the villages. Households in the farming system zones have limited post-harvest activities. Yam, cocoa and other tree crops were found to provide those engaged in their production with good income annually but the income is not frequent. Though taro cultivation is profitable, it does not present a general opportunity for many people as it only thrives well in valley bottom areas.

The availability of non-farm income was found not to be related to household typology. On average, 52 percent of households have non-farm income while 48 percent do not. Thirty-seven percent of poor households have non-farm income against 62 percent of intermediate households. Surprisingly, 67% of rich households have no non-farm income. It can therefore be said that wealth status is not determined by the extent of diversification into non-farm activities in the two farming system zones. The percentage of farmers in non-farm activity is, however, higher in areas that are characterised by a single farming season.

Generally, crop farming constitutes the major economic activity in most areas. However, focusing on traditional cropping activities makes the farmers vulnerable to economic and climatic shocks. Crop failure is on the increase due to land degradation, population growth, and climate change. Very few farmers are diversified, which reduces their production and financial risk. Differences in livelihood strategies lie in the differences in household resource endowment, institutional linkages, infrastructural development, and nearness to major marketing centre among others.

Motivation for SFC

Several factors motivated the farmers who adopted SFC in the study area. Regular flow of income, which comes from quick maturing crops like vegetables, and crops that have good yields with high demand and competitive pricing system are attractive to farmers. The need to come out of poverty was an important factor that motivated them to adopt SFC. Increase in income levels is therefore a major driving force. In addition, to women, economic independence is greatly desired either because they perceive that their husbands alone could not cope with the financial demands of the household or they are not in favour of requesting financial assistance from their husbands for every minor need. Women are attracted to high value crops which do not require large land holdings.

Vegetable production was therefore attractive to land poor farmers as it does not require large acres of land to adopt. It also does not hold the land for a long period of time. Belonging to an association is another major motivation as it is an effective means of obtaining credit and farmer information on inputs and prices.

The movement of households from one farming system zone to settle at another led to the introduction of new crops in areas where they were not previously cultivated. An example is the introduction of beans and tomatoes production in the transition zone by settlers from Northern Ghana. The example of pepper in the forest zone by migrants from the Brong-Ahafo Region was mentioned earlier. The settler farmers explain the system of cultivating the new crop and farm households observe their cultivation and profitability. The profitability of a crop serves as an incentive for adoption or at least trial.

The level of profitability of the new crops, mostly high value crops which have good yields, is directly related to appropriate farm management practices. For example, vegetables are less resistant to harsh environmental conditions and require more care and attention. The attention includes frequent weeding, spraying against insects and diseases, fertilisation, and prompt harvesting. For those who adopt vegetable production, SFC has compelled them to adopt good farm management practices.

Farmers are aware that the production of non-staple or non-traditional crops can generate higher incomes. The reasons for adoption and the characteristics of adopters and non-adopters are presented in Table 2. Commercialisation has resulted in improved income levels that have enabled households to build houses, purchase pumping machines, some have purchased vehicles, cater for children, cater for themselves, and to improve household nutrition. Adopters of commercialisation had improved living standards than non-adopters.

Barriers to participation in commercialisation activities

The pathways of commercialisation often demands capital and labour as well as a thorough supervision of the process. Determination is necessary to adopt SFC. Access to credit and other means of financial support are necessary to enable farmers consider adopting commercialisation. Otherwise, community members who are resource poor are unable to participate. SFC requires large outlays of capital to purchase fertilizer and agro-chemicals, and to pay for labour services. Apart from credit, some farmers do not have fertile land on which to cultivate vegetables.

There is some degree of uncertainty in adopting vegetable production as output price is sometimes unfavourable. Farmers sell even when the price is very low because the produce is perishable and not stored or processed within the local setting. Farmers incur large losses when traders fail to come and buy the produce. Alternative marketing avenues need to be explored besides the role of the middleman.

Small-scale farmers are rather unwilling to purchase food items which they can grow themselves. This is

Table 2. Reasons for adoption and characteristics of adopters and non-adopters.

Adopters	Non-adopters
Characteristics	
• Have more income and own properties such as houses, television, and fridges. • Give better education to children. • Provide good and nutritious food for their family. • Good physical appearance (clothing). • Less borrowing	• Low income levels • Not able to educate children to higher levels. • Not able to provide good and nutritious food for the family. • Poor physical appearance (clothing). • Borrows money often.
Reasons for adoption and non adoption	
• The quest for better standard of living. • The need to get quick income to meet financial expenses, especially to pay for children's education. • In the case of vegetables, it is early maturing and can be harvested every week.	• Have another viable enterprise (taro, cocoa, oil palm, cassava and maize) • Adoption needs a lot of labour and capital. • High cost of chemicals and fertilizers. • Very intensive and difficult to undertake – requires hard work. • No interest in vegetable production. • Few fertile lands that can support such production activities.

particularly important considering their risk averse behavior. This confirms conclusions of a study by Drafor et al. (2013), which analysed the behavior of rural households in ensuring food security in lean seasons and showed that rural small-scale farmers will produce rather than purchase staples for household consumption under different policy scenarios. Consequently some community members in the farming system zones, especially the land poor, are hesitant to adopt SFC due to its implications for food security.

In communities where vegetable production is widespread, SFC is said to result in food shortages as vegetables are not consumed in large quantities and most of the fertile land is devoted to its production. Households involved in food production are key contributors to making commercialisation possible due to the complementary role they play in contributing to food security.

Gender impacts in agricultural commercialisation

The transformation of traditional farming economies into modernized small-scale farming has cultural implications, including important changes in indigenous patterns of gender relationships within the household and the community. The ability for women to move into commercial production requires resource availability, access to new technologies and market opportunities. Women often need to adopt strategies that allow them to bypass gender constraints to enable them have access to land, capital and other productive resources.

The key aspects of impact of SFC are increase in income, change in social status, economic and financial independence, empowered decision-making position and gender equity. Some of these are particularly more important for women than men who usually play leadership and decision-making roles in society. Women adopters had better financial independence which improved their status in the household and community, especially when they control income generated from commercialisation activities.

Ability to control income from SFC activities depends on whether the activity was carried out as a household or at individual level. Most families farm together as a team, though there are individual farms. Many women also have their own farms. Access to and control of resources depends on who controls the income from economic activities in the household. Household members who have control over the income from SFC are able to rent land and hire labour, purchase fertilizers, agro-chemicals and farm equipment. As such, lack of control of income is directly linked with lack of access to productive resources. However, it was found that before some women could get access to a knapsack sprayer or a pump for work on their vegetable farm, they have to work for three days on the farm of the one who owns it. She is then allowed to have user access to these resources.

When both the man and the woman undertake commercialisation activities, they bring their resources together to educate their children and for the general welfare of the household. Children help on the farm after school and the entire household benefits. In the past, a division of labour existed, but everybody worked for the direct survival of the family – men, women and children. With the introduction of cash crops, women's responsibility to provide the required food crops increased, while men's main responsibility shifted to the

production of cash crops, often with considerable labour contributions from women. An earlier study by Saito et al., (1994) showed that the introduction of cash crops resulted in the weakening of the traditional gender division of intra-household rights and obligations and farm women increasingly undertook tasks previously done by men.

There are changes in intra-household division of labour with the introduction of profitable commercialisation activities. In the study sites, women undertake the harvesting and marketing activities while the men carried out the land clearing, chemical application and some harvesting. The children do the planting and fertilizer application. In Nyansuaka and Ampenkro, women do most of the work on the farm after the men clear the land. With time, when more money is obtained from SFC activities, women and children work less on the farm in male-headed households since there is money to hire labour. When there is limited household income in the face of increasing farm size, women work more in the farm, which could affect the time left for them to undertake household activities. On the other hand, women in female-headed households (single women, the divorced, the separated and women with absentee husbands) work more on the farm with the introduction of SFC. Challenges in intra-household relationships stern from situations in which men complain of disrespectful behaviour from women whose income level have increased. Women also complain that some married men put pressure on the family when they adopt SFC by taking concubines.

Adoption of SFC is a gain to an entire village community. Inter-household relationships are strengthened through various forms of inter-dependence and collaboration. Non-adopters, including the youth, are employed to undertake various activities, for which they are paid either in kind or in cash. Borrowing from community members reduces as a result of financial independence of adopters. Adopters of SFC are major financial contributors towards community development, contributing more to enhance progress in the villages. This impact on community development is very important, especially with limited national development efforts in rural areas. Besides, SFC serves as motivation to stay in the villages and has resulted in reducing rural-urban migration.

CONCLUDING REMARKS

If we want agricultural growth to reduce poverty, it must be inclusive, leaving no real alternative to a smallholder-led agricultural development strategy (Jayne, et al. 2011). Interactions and interconnectedness of rich farmers and poor farmers can result in effective rural development and growth, without which many poor households can be left out completely. The outcome of small-farmer commercialisation in two farming system zones reveals that entire communities benefit from SFC due to inter and intra-household relations.

There are a number of factors that motivate the adoption of small-farmer commercialisation in rural Ghana. Small farmers are attracted to activities that will bring quick and regular income, and which do not need large acres of land. Vegetables and maize satisfy these conditions. Farmers moving from one community to settle in another results in the introduction of new crops in the new communities, thus promoting small-farmer commercialisation. Membership of groups is also an advantage in benefiting from SFC activities in the farming system zones as it does not only encourage adoption of SFC, but also facilitates the process of obtaining credit and good prices. For maize however, production of a marketable surplus is key to improving income.

Women's entry into commercial agriculture is individual and therefore sustainable. Furthermore, the presence of SFC enhances gender equality and the empowerment of women in rural areas. When women have access to and control enterprises, resources and revenue from commercialisation activities, it enables them to achieve financial independence, increased social status and integrates them better into national and global markets. This process promotes the empowerment of woman in the agricultural sector.

Some of the advantages of adopting SFC can only be derived through the simultaneous adoption of improved farm and production management practices. SFC has compelled farmers to adopt better farm practices, which is unavoidable for vegetables as they are less resistant to harsh environmental conditions and require more care. Adoption of good agricultural practices can be increased if more farmers are given incentives to adopt SFC.

Small-farmer commercialisation improves the livelihood of rural households but requires access to productive resources and services. Access to credit and effective markets can serve as incentives for more women adopting SFC, leading to improved incomes, better social status, financial independence, and greater gender equality. SFC is generally capital intensive and many smallholders are unable to meet the high production costs from their own savings. It follows that rich households are more able to adopt SFC activities that require large capital outlays, followed by intermediate households. The role of credit and small starter packs are increasingly relevant for enhancing smallholder adoption of SFC. Poverty and the absence of alternative income sources in rural areas compel farmers to sell their produce early, limiting their ability to benefit from higher prices in lean seasons.

From the example of the pepper producers in the forest zone, market access, which addresses the role of middlemen that can diminish farm incomes, is a vital factor for successful commercialisation of agriculture. Consistent with Weinberger and Lumpkin (2007), market

integration of vegetable producers is higher than that of staple crop producers. A revisit of the system of marketing agricultural products across the country with specific policies that protect the interest and income of small-scale farmers is an urgent need. Effective marketing systems and alternative avenues for value addition for vegetables should be explored due to their perishable nature.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Adenegan KO, Adams O, Nwauwa LEO (2013). Gender Impacts of Small-Scale Farm Households on Agricultural Commercialisation in Oyo State, Nigeria. Br. J. Econ. Manage. Trade 3(1):1-11.

Alene DA, Manyong VM, Omanya G, Mignouna HD, Bokanga M, Odhiambo G (2008). Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya. Food Pol. 333:18-328.

Berhanu G, Jaleta M (2010). Commercialization of smallholders: Does market orientation translate into market participation? Improving Productivity and Market Success (IPMS) of Ethiopian farmers project Working Nairobi, Kenya, ILRI. P. 22.

Drafor I, Kunze D, Sarpong D (2013). Food Security: How Rural Ghanaian Households Respond to Food Shortages in Lean Season. Int. J. Agric. Manage. 2(4):199-206. DOI: 10.5836/ijam/2013-04-03. http://dx.doi.org/10.5836/ijam/2013-04-03

Fischer E, Qaim M (2012). Gender, agricultural commercialization, and collective action in Kenya. Food Sec. 4(3):441-453.

FAO (2011). The State Of Food And Agriculture 2010-11: Women In Agriculture Closing the Gender Gap *for* Development. Rome: FAO.

FAO (1997). Gender: The key to Sustainability and Food Security. SD Dimensions/ Women and Population/Special. www.fao.org/WAICENT/FAOINFO/SUSTDEV/Wpdirect/WPdoe001.htm.

Heltberg R, Tarp F (2002). Agricultural supply response and poverty in Mozambique. Food Pol. 27:103-124.

Hunt J (2004). Introduction to gender analysis concepts and steps. Dev. Bull. 64:100-106. Accessed on August 26, 2013. Available at: http://www.vasculitisfoundation.org/wp-content/uploads/2012/11/development_studies_network_intro_to_gender_analysis.pdf.

IFAD (2012). Grants: An overview. Accessed on March 18, 2013. Available at: http://www.ifad.org/operations/grants/index.htm.

IFAD and AfDB (2010). Towards purposeful partnerships in African agriculture: A joint evaluation of the agriculture and rural development policies and operations in Africa of the African Development Bank and the International Fund for Agricultural Development. Accessed on December 20, 2012. Available at: http://www.ifad.org/evaluation/jointevaluation/docs/africa/africa.pdf.

Jayne TS, Haggblade S, Minot N, Rashid S (2011). Agricultural Commercialization, Rural Transformation and Poverty Reduction: What have We Learned about How to Achieve This? Synthesis report prepared for the African Agricultural Markets Programme Policy Symposium, Alliance for Commodity Trade in Eastern and Southern Africa April 20-22, 2011, Kigali, Rwanda.

Phillips SP (2005). Defining and measuring gender: A social determinant of health whose time has come. Int. J. Equity in Health, 4(11):1-4. doi:10.1186/1475-9276-4-11. http://dx.doi.org/10.1186/1475-9276-4-11

Pingali PL, Rosegrant MW (1995). Agricultural commercialization and diversification: processes and policies. Food Pol. 20(3):171-185,

Quisumbing AR, Meinzen-Dick RS (2001). Empowering Women To Achieve Food Security: Overview. FOCUS 6 • Policy Brief 12. International Food Policy Research Institute, Washington DC.

Quisumbing AR, Brown LR, Feldstein HS, Haddad L, Pena C (1995). Women: The Key to Food Security. Food Policy Statement No. 21, Aug. 1995. International Food Policy Research Institute, Washington, DC.

Saito AK, Mekonnen H, Spurling D (1994). Raising the Productivity of Women Farmers in Sub-Saharan Africa. World Bank Discussion Papers. Africa Technical Department Series, P. 230. Washington DC.

Timmer P (1997). Farmers and Markets: The Political Economy of New Paradigms. Am. J. Agric. Econ. 79(2):621-627

United Nations Development Programme (UNDP) (2012). Africa Human Development Report 2012: Towards a Food Secure Future. UNDP Report.

von Braun J, Kennedy E (Eds.) (1994). Agricultural commercialization, economic development and nutrition. Johns Hopkins University Press for the International Food Policy Research Institute, Baltimore and London.

Webb P (1989). Intrahousehold Decisionmaking and Resource Control: The Effects of Rice Commercialization in West Africa. International Food Policy Research Institute, Washington DC.

Weinberger K, Lumpkin TA (2007). Diversification into horticulture and poverty reduction: A research agenda. World Dev. 35(8):1464-1480. doi:10.1016/j.worlddev.2007.05.002.

WFP (2012). Purchase for Progress: Gender. Accessed on December 28, 2012. Available at: http://documents.wfp.org/stellent/groups/public/documents/reports/wfp252603.pdf.

Wiggins S, Argwings-Kodhek G, Leavy J, Poulton C (2011). Small farm commercialisation in Africa: Reviewing the issues. Future Agricultures Consortium, Research Paper.

World Bank (2011). World Development Report – 2012 – Gender Equality and Development, Washington D.C.: World Bank

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Empirical investigation of the dynamic linkages between crude oil and maize prices: Dating the structural breaks

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The main purpose of this paper is to analyze the long- and short-run effects of crude oil prices on maize prices, taking into consideration the possible structural breaks in the relationship between them. Time-series analysis was used to estimate the dynamic linkages between variables under examination, while the Bai and Perron procedure was applied to endogenously identify the turning points. Data employed were collected from the World Bank's database Global Economic Monitors (GEM) for commodities, covering the time period from January 1960 to December 2012. The structural break was dated in early 2005, when the ethanol mandate in the US Energy Policy Act became effective. Empirical results from cointegration analysis support the hypothesis that crude oil prices consistently affect maize prices and this relationship has strengthen after the biofuel mandate in 2005 was issued in the US. Furthermore, the estimation of the ECM suggests that any deviation from equilibrium is corrected with nearly 48% over the following year. The results may call for serious policy implications. Directives and legal framework supporting the production and use of bioethanol should take into consideration the possible effect on food prices and especially grains, usually used for biofuel production.

Key words: Crude oil, maize, cointegration, Bai and Perron, structural breaks.

INTRODUCTION

During 2006-2008 the world experienced unprecedented increases in basic food prices, raising concerns about world food security, hunger and poverty around the world. One factor highlighted as the main cause of increased food prices was the steep rise in crude oil prices. Agriculture, historically, has been an energy intensive sector. From fertilizers to long distance transportation, agricultural sector includes many energy-dependent procedures, through which the price transmission from one sector to other occurs. According to Hanson et al. (1993), increases in crude oil prices are followed by higher costs, resulting in rising agricultural prices.

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Moreover, spikes in crude oil prices offered the motivation for the production of biofuels contributing to the further rise of food prices and also to a closer link between energy and agriculture (Cooke and Robles, 2009). Biofuel industry uses staple food, such as grains, rice, sugar and vegetable oils, as a basic input in the production procedure. Subsequently, the increased demand for grains contributed to soaring food prices and also to increased integration between energy and agriculture. According to Runge and Senauer (2007), this combined effect of high crude oil prices and large subsidies for supporting bioethanol produced from maize led to the observed expansion of the biofuel sector.

Motivated by the increased integration between energy and agriculture and the following impact on food prices, we investigate the long-run relationship between crude oil and maize prices using time-series analysis. Despite the fact that there is a vast bibliography concluding that a cointegration relationship between energy and agricultural prices exists no one, to our concern, has tested for the long-run stability of these relationships. More specifically, because the development of oil and agricultural prices has not occurred in a completely uniform manner, but rather has experienced important external shocks and increased volatility, previous results for cointegration might have been misleading. For this reason, we apply the Bai and Perron (1998, 2003a) procedure to endogenously identify structural breaks in the relationship between crude oil and maize international prices and, then, the structural breaks are included in the cointegration equation. The cointegration analysis is repeated using the more reliable technique of Fully-Modified OLS (Phillips and Hansen, 1990), while we apply the Hansen (1992) and Phillips and Ouliaris (1990) instability tests to reveal the long-run stability of this relationship. Finally, we investigate the short-run dynamics estimating the error correction model and applying Granger causality tests.

The reason for choosing maize over other grains is very specific. First of all, maize is the basic input in bioethanol production, which represents the largest share of global biofuel supply, nearly 84% of total biofuels production (Currie et al., 2010). Secondly, the ethanol production demonstrated a steep increase during 2000-2008 in the US, while the use of corn in ethanol production rose from 6 to 37% during the same period (RFA, 2009).

Our empirical results provide support for the existence of a stable long-run cointegration relationship between maize and crude oil prices with one structural break, which found to be statistically significant and identified in the beginning of 2005, when the ethanol mandate in the US Energy Policy Act became effective (Krugman, 2008; Mitchell, 2008; de Gorter et al., 2013). These findings support the hypothesis that crude oil prices consistently affect maize prices and this relationship has strengthen after the biofuel mandate in 2005 was issued in the US.

LITERATURE REVIEW

Links between energy and agriculture: Focusing on the 2008 price crisis

Historically, agriculture has been an energy-intensive sector and the investigation of the degree on which changes in energy prices and policies affect agricultural prices or agricultural sector overall has been of primary interest. Since the 1970s, researchers try to examine the certain channels through which agriculture and energy are linked. For example, a study by Chenery (1975) highlighted the distortion in international trade caused by increased energy and food prices and the following negative implications especially for developing countries.

During 2006-2008, dramatic increases in staple food prices raised the world's attention upon a forthcoming food price crisis with devastating implications for food security, hunger and poverty, especially for poorer households in developing and, also, in developed countries. Today nearly 800 million people suffer from chronic hunger and undernourishment, while the rise in basic foodstuff prices is expected to add some more (FAO, 2008). The deprivation of millions of people from the most basic human right, access to food, caused bloody classes and social turmoil globally. According to Bush (2010), the so-called "foodriots" highlighted the social and economic consequences of a dramatic increase in food prices.

More specifically, prices in the three basic commodity groups, energy, metals and agriculture, experienced substantial rises after a long-run downward trend, following a very similar pattern, as illustrated in Figure 1. High energy and metal prices, led by unprecedented rises in crude oil prices, seem to have occurred simultaneously with increases in agricultural prices, especially grains, rice and sugar. To be exact, crude oil prices reached their peak, at nearly $133/bbl on July 2008 from just $60.6/bbl on March 2007, while maize prices were more than doubled within a year, between June 2007 and June 2008 (Figures 2 and 3).

Many factors were proposed as causes of soaring food prices, from the demand and also the supply side of agricultural sector. Such factors include the increased demand from emerging markets, such as China and India, and changes in consumer preferences towards meat and dairy products due to rapid growth rates, higher per capita incomes and improved standards of living. Other factors include supply constraints due to extreme weather conditions, such as extended periods of drought in large producer countries, low investment in R&D in agriculture, implementation of restrictive trade policies by governments, such as import tariffs or export restrictions and the increased speculation in commodity markets.

However, the steep rise in energy prices, and especially crude oil prices, highlighted as one of the main reasons behind the drastic food price increases by a

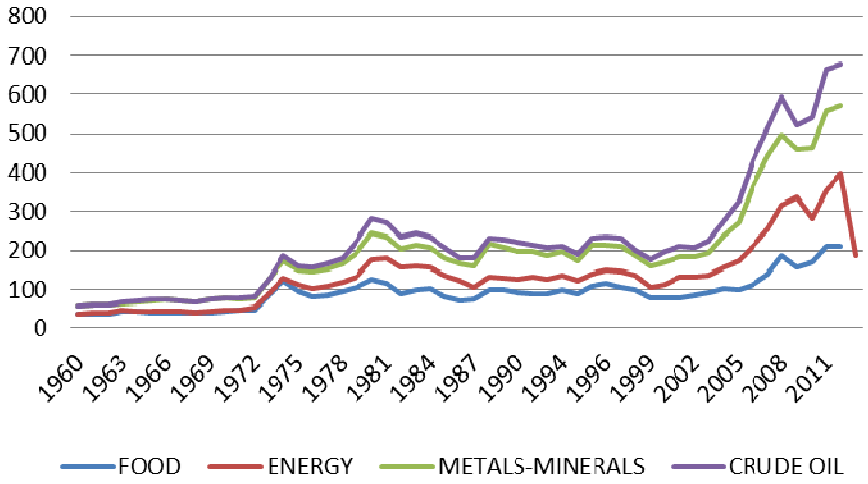

Figure 1. Food, energy, metals-minerals and crude oil prices, 1960-2012, 2005=100, $ nominal.

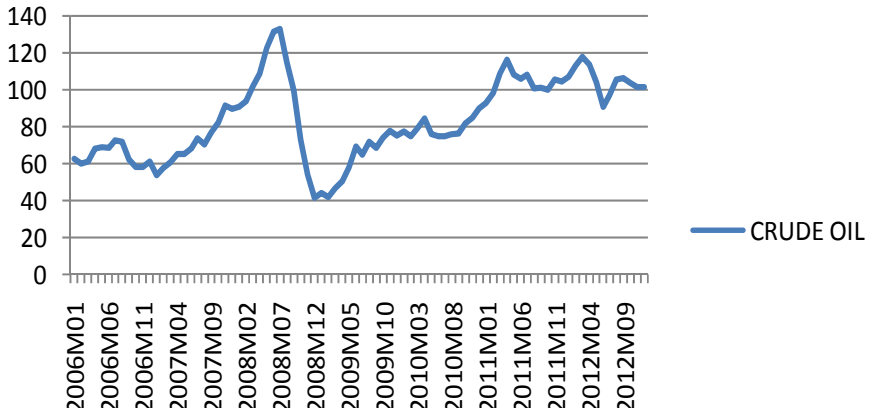

Figure 2. Crude oil, average spot, nominal prices $/bbl, 2006M01-2012M12.

Figure 3. Maize, nominal prices $/mt, 2006M01-2012M12.

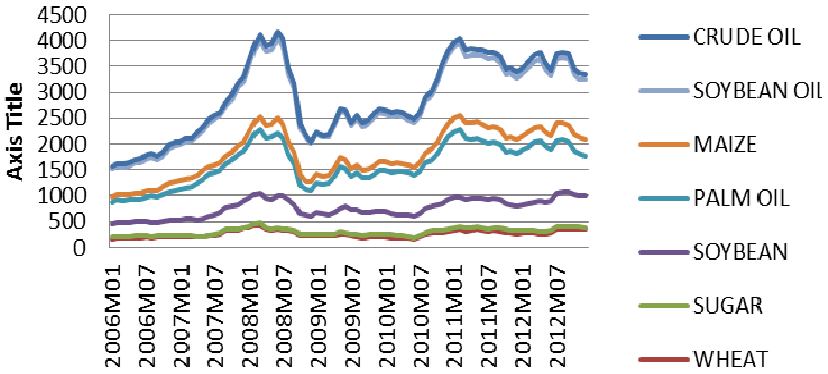

Figure 4. Crude oil, nominal prices $/bbl, maize, palm oil, soybean, sugar, wheat, nominal prices $/mt, 2006M01-2012M12.

large part of the research. According to Piesse and Thirtle (2009), high energy prices was the most crucial factor behind high food prices and, because we expect them to rise more in the future, policy measures should focus on improving the production conditions in global agriculture. It is true to say that energy prices can affect agricultural prices through many channels, while the most apparent one is through production costs. According to Hanson et al. (1993), increases in crude oil prices are followed by higher costs, resulting in rising agricultural prices.

Moreover, this increase is expected to be fairly substantial as agricultural production includes many energy-intensive procedures, from fertilizers to long-distance transportation. For this reason, crude oil prices should be included in the aggregate production function of most agricultural products (Baffes, 2007). Fertilizers, fuels and transportation costs are affected directly by crude in oil prices, and turn, they affect grains production (von Braun et al., 2008). For Chevroulet (2008), the distribution of agricultural production in spatially distributed consumers in urban places will include significant transportation costs, highly dependent on fuel prices.

Moreover, higher prices of conventional energy during the last price crisis provided a strong motivation for the production of alternative fuels, such as biodiesel and bioethanol (Cooke and Robles, 2009). Indeed, this shift in profitability is apparent from older studies; Lunnan (1997) identifies the high biofuel production costs in relation to oil costs as the main prohibitive factor for their expansion. In addition, policy measures and directives in Europe, the US, Japan and Brazil contributed significantly towards this direction by making the production and usage of biofuel obligatory for environmental mainly reasons. According to Runge and Senauer (2007), this combined effect of high crude oil prices and large subsidies for supporting bioethanol produced from maize led to the observed expansion of the biofuel sector.

Figure 4 illustrates the monthly price movement of staple food usually used in biofuel production, like grains, sugar and vegetable oils from 2006-2012, and also crude oil prices per barrel. As it is clear, prices in food commodities and energy followed a very similar pattern, experiencing enormous increases during 2006-2008.

Empirical investigation of the oil-food interdependencies

The investigation of the impact that increased oil prices have on food prices is primarily based on three different methodologies. Firstly, part of the research uses Computable General Equilibrium models (CGE) to simulate the links between energy and agriculture on a macroeconomic level and capture the effects of changes in energy prices on real income and on trade balances. However, despite the fact that such analysis takes into consideration the interdependencies between sectors, it lacks in revealing the short term impacts. In addition, most of the relationships are exogenously determined by economic theory (Zhang et al., 2009).

More recently some researchers tried to assess the impact of energy on agriculture using theoretical models. The most important disadvantage of theoretical models is that the results are highly depended on the assumptions made and the certain structure of the model. More specifically, Gardner (2007) examines the welfare effects of corn and ethanol subsidies in the US by developing a theoretical model of the ethanol, maize and by-products markets, while de Gorter and Just (2009), expand Gardner's model incorporating the ethanol market into the aggregate fuels market and suggest that the price transmission between fuel and maize takes place through the corn demand for ethanol production.

The third methodology that has been used by researchers is cointegration analysis. These studies usually concentrate on the consequences of increased energy prices on certain commodities involved in the biofuel production, such as grains or sugar and vegetable

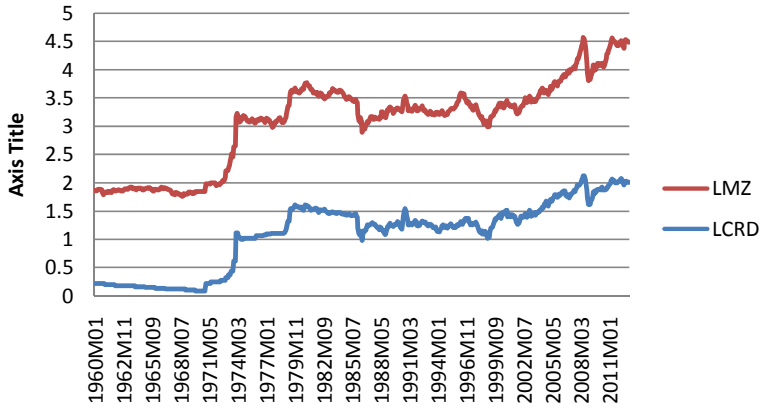

Figure 5. LMZ and LCRD 1960:01-2012:12.

oils using cointegration analysis and also for certain countries or groups of countries. Again, the results vary based on the data and methodology employed, time period and commodities under consideration.

Yu et al. (2006) use weekly data from January 1999 to March 2006 and apply Johansen cointegration methodology to examine the dynamic linkages between international crude oil prices and basic edible vegetable oils, such as soybean oil, sunflower oil, rapeseed oil and palm oil. Their results indicate that shocks in crude oil prices do not affect significantly the agricultural prices. Campiche et al. (2007), also apply the Johansen analysis to investigate the dynamic relationship between crude oil and five agricultural commodities, namely corn, sugar, soybean, palm and soybean oil for the period 2003-2007. They do not find cointegration relationship when the whole time period is taken into account; however, their results reveal that crude oil and agricultural prices are cointegrated for the period 2006-2008. Zhang and Reed (2008) investigate the impact of international crude oil prices on maize, soybean and pork prices in China. Using data for the period January 2000-October 2007, they apply VARMA models, Granger causality tests, variance decomposition and cointegration analysis concluding that the fuel prices did not affect significantly the food prices in China.

On contrary, other studies provide evidence for the existence of a long-run relationship between energy and agricultural prices. Hameed and Arshad (2008), apply the Engle and Granger cointegration methodology to examine the long-run relationship between crude oil prices and four vegetable oils for the time period from January 1983 to March 2008. Their results indicate the existence of a long-run cointegration relationship between crude oil and each vegetable oil, while the estimation of error correction models reveals causal relationships running from crude oil prices to agricultural commodities under examination. Saghaian (2010), uses monthly data for maize, wheat, soybean, crude oil and ethanol prices to test the reaction of agricultural prices in crude oil price changes. The results from the VEC Models indicate a strong correlation between agricultural and energy prices, however, the Granger causality tests provide mixed results. Elmarzougui and Larue (2011), investigate the relationship between international corn and crude oil prices from January 1957 to April 2009 and find three structural breaks using the Bai and Perron procedure (1998, 2003). Their empirical results provide support for the existence of a cointegration relationship only during the third regime, from 1990 to 2009, indicating that the emergence of the biofuel industry contributed to a stronger link between them.

METHODS

Data

The data employed in our analysis are monthly covering the time period 1960M01 to 2012M12 and are collected from the World Bank's database Global Economic Monitors for Commodities. The variables included are international nominal prices for maize (LMZ) and crude oil (LCRD). Moreover, maize prices refer to US, No.2, Yellow, FOB prices, while for crude oil we use the average spot price of Brent, Dubai and West Texas Intermediate, equally weighed. Both variables are used in their physical logarithms (Figure 5).

Stationarity and cointegration analysis

Cointegration refers to the possible comovement among certain variables in the long-run horizon. Furthermore, if maize and crude oil prices are found to be cointegrated means that, despite the fact that they may drift apart temporarily from each other, in the long-run they tend to return to equilibrium. In the context of this paper, we apply the residual-based tests for cointegration proposed by Engle-Granger and Phillips-Ouliaris, which require for variables to be integrated of order one, I(1) in order to avoid a spurious regression (Granger and Newbold, 1974). We apply Dickey and Fuller's (1979, 1981) unit root tests to find out if our variables are stationary of order one, I(1). If this is the case, we can proceed with testing for the possible existence of a long-run equilibrium relationship between maize and crude oil prices with Engle and Granger's (1987) and Phillips and Ouliaris' (1990) single equation

cointegration tests. Engle-Granger (1987) and Phillips-Ouliaris (1990) residual-based tests for cointegration are simply unit root tests applied to the residuals obtained from OLS estimation of equations:

$$LMZ_t = \alpha_1 + c_1 LCRD_t + u_t \quad (1)$$

$$LCRD_t = \alpha_2 + c_2 LMZ_t + e_t \quad (2)$$

By obtaining the estimated residuals form the cointegration Equations (1) and (2) $\hat{u}_t = LMZ_t - \hat{a}_1 - \hat{c}_1 LCRD_t$ and $\hat{e}_t = LCRD_t - \hat{a}_2 - \hat{c}_2 LMZ_t$ respectively, we apply unit root tests for stationarity. The null hypothesis of no cointegration against the alternative of cointegration corresponds to a unit root test of the null of no stationarity against the alternative of stationarity.

Bai-Perron procedure for endogenous structural breaks

The previous results might be misleading as the development of prices over the years has not occurred in a completely uniform manner, but rather it has experienced important external shocks. If this is the case, the existence of a cointegration relationship between the variables under examination will not have been a stable one.

Motivated by this observation, in the next step we apply Quandt's (1960) likelihood ratio statistic (QLR) to test parameter's stability and identify possible structural change points in the long-run relationship between LMZ and LCRD. However, because Quandt's statistic has received criticism due to the difficulty in deciding the pre-determined structural turning point, we apply the Bai and Perron (1998, 2003a) procedure to endogenously identify multiple breakpoints. The BP methodology uses statistical inference to date a specific break by calculating thousands of values of SSE (Sum of Squared Residuals) under different assumptions in order to find the minimum one. Each of SSE is calculated by summing up all the squared residuals in all regimes and each residual represents the difference between an observed data series and its corresponding mean in a regime. It is more than apparent that the SSE will be minimized when we date the exact structural breaks for a data series. This concept implies that the breaks are selected by repeatedly testing all possible points according to the relevant significance of certain statistical tests.

For the purposes of this paper we use the sequential *SupF(l+1|l)* test, where the null hypothesis of l structural changes is tested against the alternative of $l+1$ breaks. If the statistical test *SupF(l+1|l)* is found to be significant, then we accept the hypothesis for the existence of at least $l+1$ turning points. The procedure is repeated until the number of structural changes is endogenously determined.

Cointegration analysis with structural breaks

Taking into account the structural breaks determined in the previous stage, we test for the existence of a long-run cointegration relationship between maize and crude oil prices, using the more credible Phillips and Hansen's (1990) Fully-Modified OLS (FMOLS) methodology. More specifically, Phillips and Hansen propose an estimator which employs a semi-parametric correlation to eliminate the problems caused by the long run correlation between the cointegrating equation and stochastic regressors innovations. The resulting estimator is asymptotically unbiased and has fully efficient mixture normal asymptotics allowing for standard Wald tests using asymptotic Chi-square statistical inference. Then, we proceed with testing the long-run stability using Hansen's (1992) and Phillips-Ouliaris (1990) instability tests. Hansen (1992), tests the null hypothesis of cointegration against the alternative of no cointegration proposing the L_c statistic which arrives from the theory of Langrage multipliers, in order to assess the stability of the parameters. He notes that under the alternative hypothesis of no cointegration, one should expect evidence of parameter instability. On the contrary, Phillips and Ouliaris (1990) test the reverse null hypothesis of no stable cointegration against the alternative of a stable cointegration using the statistics Phillips-Ouliaris tau and z.

Estimation of error correction models and granger causality tests

In the last step of our analysis, it is appropriate to estimate the error correction models derived from Engle and Granger methodology including the structural breaks in order to investigate the long- and short-run dynamics between our variables. According to Granger's Representation Theorem, in case that cointegration is detected, an Error Correction Model (ECM) exists:

$$\Delta Y_t = \beta_1 \Delta X_t - (1-\gamma_1)(Y_{t-1} - \alpha_0 - \alpha_1 X_{t-1}) + \varepsilon_t \quad (3)$$

$$\Delta Y_t = \beta_1 \Delta X_t - (1 - \gamma_1)\hat{u}_t + \varepsilon_t \quad (4)$$

Where $\hat{u}_t = Y_t - \hat{a}_0 - \hat{a}_1 X$, the estimated residuals derived from the first step of the Engle and Granger methodology. All variables in Equation (4) are stationary, as Y and X are cointegrated. Furthermore, as one can see, changes in Y are dependent on changes in X and also the disequilibrium error of the previous period. This means that the value of Y is being corrected for the disequilibrium error of the previous period, however, the correction is partial and depends on the value of γ_1, for which we assume that $0<\gamma_1<1$. More specifically, we derive the long-run dynamics by estimating the error correction term, γ_1, which represents the speed at which the dependent variable, maize price, returns to equilibrium after a shock experienced in crude oil prices. According to the above, we expect for the coefficient of the error correction term to be negative and statistically significant. Additionally, the dynamic ECM incorporates, also, the short-run effects by including the variables in differences.

With regard to the short-run causality between the variables under examination, we apply the Granger-causality (1969) test based on the previous error correction model. More specifically, we want to reveal how much of the current value of our dependent variable can be explained by the past value of the second variable and to see whether adding lagged value can improve the explanation. This is examined with a simple F-test, where the null hypothesis to be tested is that petroleum price does not Granger-cause maize prices or maize price does not Granger-cause crude oil price.

RESULTS AND DISCUSSION

Stationarity and cointegration tests

Table 1 summarizes the results from the unit root tests on the levels and the first differences of the variables. Both variables are nonstationary in levels (test statistic >critical value), while they turn stationary in first differences (test statistic < critical value). The variables under examination are integrated of order one, I(1), thus we can proceed with cointegration testing. The results from Engle-Granger and Phillips-Ouliaris tests are presented in the

Table 1. Augmented Dickey-Fuller unit root tests.

Series in logarithm	Include an intercept, but not a trend			Include an intercept and a trend		
	Test statistic	k	Critical value	Test statistic	k	Critical value
LCRD	-0.8419	6	-2.8982	-1,7728	6	-3.5260
LMZ	-1.5676	1	-2.8718	-2.8550	1	-3.4894
Series in first difference	**Test statistic**	**k**	**Critical Value**	**Test statistic**	**k**	**Critical value**
ΔLCRD	-11.0270	5	-2,8545	-11.0181	5	-3.4711
ΔLMZ	-19.3089	0	-2.8551	-19,2990	0	-3.4529

The optimal lag structure of the ADF test is chosen based on the Akaike Information Criterion (AIC), while k denotes lag order. The critical values are 95% simulated critical values using 40 obs. and 1000 replications.

Table 2. Residual-based tests for cointegration.

Dependent variable	Engle-Granger's residuals unit root[1]		Phillips-Ouliaris' residuals unit root[2]	
	t-statistic	p-value	t-statistic	p-value
LMZ	-4.089	0.0057	-3.921	0.0098
LCRD	-3.853	0.0121	-3.685	0.0200

[1]Lag specification based on SIC (maxlag=19), Ho: Series are not cointegrated; [2]Long-run variance estimate (prewhitening with lags = 0 from SIC, maxlags = 1, Bartlett kernel, Newey West fixed bandwidth, Ho: Series are not cointegrated; p-values: based on MacKinnon (1991).

Table 2.

P-values suggest that the null hypothesis of no cointegration is rejected with both methodologies and for both equations; when dependent variable is LMZ and also when dependent is LCRD (p-value < 1 or 5% level of significance). This means that a long-run cointegration relationship exists between our variables. Crude oil and maize prices seem to have followed a similar pattern on the long-run. However, these findings might be misleading if the variables under examination have experienced important external shocks, which means that the relationship between them has not been a stable one. Given the fact that crude oil and agricultural prices are consistently affected by external factors and seasonality, we continue on with dating the structural breaks in the relationship between them.

Endogenous structural breaks with Bai-Perron procedure

Results from QLR test in Table 3 confirm the existence of at least one possible structural turning point in the relationship between variables under consideration (F-statistic>critical value at 1% level of significance). However, because QLR test has received criticism as regards the pre-determination of the turning point, we apply the Bai and Perron procedure to endogenously identify the structural breaks. Table 4 suggests the existence of 5 structural breaks in the relationship between our variables when dependent is LMZ, while the bottom part dates the specific turning points. These can now be taken into consideration in the cointegration analysis with the more reliable Fully-Modified OLS.

Cointegration with structural breaks

Table 5 summarizes the results from the estimations with FMOLS methodology. As one can observe, the variable of LCRD was found to be significant (p-value=0.0000), while most of the dummies used to represent structural breaks were rejected as statistically insignificant, except from S2005. Our results suggest that a 1%rise in international oil prices leads to a 0.27% increase in maize prices. Furthermore, the variable of petroleum price was found to be significant (p-value=0.0000) and with a positive sign, as theory suggests. Table 6 presents the results from instability tests of Hansen and Phillips-Ouliaris. Hansen's statistic, Lc, reveals a stable long-run cointegration relationship between variables under consideration. This result is supported also with Phillips-Ouliaris tests, z- and t-statistic, both of which reject the null hypothesis of no cointegration.

The analysis provides support of the hypothesis for the existence of a stable cointegration relationship between maize and crude oil prices, when maize is the dependent variable. The structural break with Bai-Perron methodology was dated in early 2005, when Energy Policy Act in the US became effective. More specifically, one important provision of the Act was the increase in the amount of biofuel that must be mixed with gasoline sold in the US. The relationship between variables under consideration seems to have strengthened after 2005.

Table 3. Quandt likelihood ratio for structural break in unknown point.

Dependent variable	Maximum F-statistic	Structural break
LMZ	111,127*	1999:07
OLS, obs. 1960:01-2012:12 (T=636), HAC standard errors, Bartlett kennel 6		
QLR test with 15% trimming, critical value at 1%: 7.78		

Table 4. Bai and Perron test for structural breaks endogenously.

Dependent variable	SupF(l+1)|1)		RSS	
LMZ	SupF(5|4)	RSS_4	16.14899	
		RSS_5	15.28508	
Dates of structural breaks				
1	**2**	**3**	**4**	**5**
1967M12	1977M04	1988M05	1997M02	2005M01

Table 5. FMOLS cointegration method.

Dependent variable	LCRD	C	S2005
LMZ	0.277553 [0.0000]	3.839[0.0000]	0.050755[0.1088]

Long-run covariance estimate: Prewhitening with lags = 1 from SIC, maxlags = 8, Bartlett kernel, Newey-West fixed bandwidth = 7.0000.

Table 6. Instability tests based on cointegration with FMOLS.

Hansen instabiltity test		**Phillips-Ouliaris test**	
H_0: Series are cointegrated		**H_0: Series are not cointegrated**	
Lc statistic	0.144102	**Phillips-Ouliaris t-statistic**	**-4.196[0.0039]**
	[> 0.2]	**Phillips-Ourialis z-statistic**	**-36.272[0.0015]**

Estimation of error correction and Granger-causality tests

In the last step of our analysis it is appropriate to estimate the error correction models derived from Engle and Granger's methodology, taking into consideration the structural break. Estimations from the EC specification are presented in Table 7. The existence of a long-run causal relationship among the examined variables is confirmed once again since the coefficient of the lagged EC term is found statistically significant (the p-value of the applied t-test is smaller than the 1%) and has the correct sign suggesting that any deviation from the long-term income path is corrected by nearly 48% over the following year.

Regarding the short-run dynamics, as reported in Table 8, there is no evidence of Granger-causality type effects running from crude oil prices to maize prices or the opposite (p-value > 1% or 5% level of significance).

Conclusion

Motivated by the increased interdependence between energy and agriculture during the last years, we used cointegration analysis in order to examine the dynamic linkages between international crude oil and maize prices from January 1960 to December 2012. In addition, we applied the Bai and Perron procedure (1998, 2003a) to endogenously identify the structural breaks in the relationship between variables under consideration.

Our empirical findings revealed a stable long-run cointegration relationship between crude oil and maize prices, when maize is dependent variable and the structural break is included in the cointegration equation. The latest was dated in early 2005, when the ethanol mandate in the US Energy Policy Act became effective and made the gasoline-biofuel mix obligatory (Krugman, 2008; Mitchell, 2008; de Gorter et al., 2013). Moreover, the estimation of the error correction specification

Table 7. VECM estimations.

Cointegrating vector	LMZ = 0.258395LCRD + 3.934764C	
Estimation of error correction term		
Dependent variable	**Coefficient**	**t-student**
ΔLMZ	-0.039830	-3.76065***

***1% significance level.

Table 8. VEC granger causality tests.

Dependent variable	Wald statistic	p-value	Outcome
ΔLMZ	3.590250	0.4643	No causality
ΔCRD	0.748505	0.9452	No causality

revealed that any deviation from the long-run equilibrium, caused by an external shock in crude oil prices, is corrected by 48% over the following year, while there was no evidence of Granger-causality type effects running from crude oil to maize prices or the opposite.

These findings support the hypothesis that crude oil prices consistently affect maize prices and this relationship has strengthen after the biofuel mandate in 2005 was issued in the US. In addition, our results may call for serious policy implications. Directives and legal framework supporting and promoting biofuel use and production should take into consideration any possible impact on food prices, and in particular, grains. Furthermore, there is an urgent need for world agriculture to become sustainable and independent from any non-renewable and conventional energy resources, like fossil fuels. On the contrary, policy should focus on supporting and compensating capital investments for the production of renewable energy and also on encouraging the recycling and reuse of agricultural by-products in order for energy needs to be covered on a natural and self-reliant way.

Conflict of Interest

The author(s) have not declared any conflict of interests.

REFERENCES

Baffes J (2007). Oil spills on other commodities. World Bank Working Paper 4333:126-134. http://dx.doi.org/10.1596/1813-9450-4333

Bai J, Perron P (1998). Estimating and testing linear models with multiple structural changes. Econometrica 66:47-78.

Bai J, Perron P (2003a). Computation and analysis of multiple structural change models. J. Appl. Econometr. 18:1-22.

Bush R (2010). Food riots: poverty, power and protest. J. Agrar. Change 10(1):119-129.

Campiche JL, Bryant HL, Richardson JW, Outlaw JL (2007). Examining the evolving correspondence between petroleum prices and agricultural commodity prices. Portland Proc. AAEA Meet. July 29-August 1.

Chenery H (1975). The structural approach to development policy. Amer. Econ. Rev. 65(2):310-316.

Chevroulet T (2008). Importance of oil price in freight transport costs. OECD/ Int. Transp. Forum, Joint Transport Research Centre, Disc. Paper, 2008-4.

Cooke B, Robles M (2009). Recent food price movements: a time series analysis. Washington IFPRI Disc. Paper, 00942.

Currie J, Nathan A, Greely D, Courvalin D (2010). Commodity prices and volatility: old answers to new questions. Goldman Sachs Global Economics, Glob. Econ. Paper, 194.

de Gorter H, Just DR (2009). The welfare economics of a biofuel tax credit and the interaction effects with price contingent farm subsidies. Am. J. Agric. Econ. 91(2):477-488.

de Gorter H, Just DR, Kliauga EM (2013). The impact of OECD biofuels policies on developing countries. Agric. Econ. 44(4):477-486.

Dickey DA, Fuller WA (1979). Distribution of the estimators for autoregressive time series with a unit root. J. Am. Stat. Soc. 75:427-431.

Dickey DA, Fuller WA (1981). Distribution of the estimators for autoregressive time series with a unit root. Econometrica 49:1057-1072.

Elmarzougui E, Larue B (2011). On the evolving relationship between corn and oil prices. Cahiers de recherche CREATE 2011-3.

Engle REC, Granger WJ (1987). Cointegration and error correction: representation, estimation and testing. Econometrica 55:251-76.

FAO (2008). The state of food insecurity in the world: High food prices and food security. Rome FAO.

Gardner B (2007). Fuel ethanol subsidies and farm price support. J. Agric. Food Ind. Org. 5(2):4.

Granger C (1969). Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37(3):424-438.

Granger C, Newbold P (1974). Spurious regressions in econometrics. J. Econometr. 2:111-120.

Hameed AA, Arshad FA (2008). The impact of the petroleum prices on vegetable oil prices: evidence from cointegration test. In: Proc. 3rd Int. Borneo Bus. Conf. (IBBC), pp. 504-514.

Hansen BE (1992). Tests for parameter instability in regressions with I(1) processes. J. Bus. Econ. Stat. 10(3):321-335.

Hanson K, Robinson S, Schluter G (1993). Sectoral effects of a world oil price shock: economy wide linkages to the agricultural sector. J. Agric. Res. Econ. 18(1):96-116.

Krugman P (2008). Running out of planet to exploit. New York Times, April 21.

Lunnan A (1997). Agriculture-based biomass energy supply: A survey of economic issue. Ener. Pol. 25:573-582.

MacKinnon JG (1991). Critical values for cointegration tests. In: Long-Run Economic Relationships: Readings in Cointegration, ed. Engle RF, Granger CWJ. Oxford University Press.

Mitchell D (2008). A note on rising food prices. Washington World Bank, Policy Resear. Work. Paper, 4682.

Phillips P, Hansen B (1990). Statistical inference in instrumental

variables regression with I(1) processes. Rev. Econ. Stud. 57:99-125.
Phillips P, Ouliaris S (1990). Asymptotic properties of residual based tests for cointegration. Econometrica 58(1):165-93.
Piesse J, Thirtle C (2009). Three bubbles and a panic: An explanatory review of the recent food commodity price events. Food Policy 34:119-129.
Quandt RE (1960). Tests of the hypothesis that a linear regression system obeys two separate regimes. J. Am. Stat. Assoc. 55:324-330.
RFA (2009). 2009 Ethanol Industry Outlook – Growing Innovation. Renewable Fuels Association, January 2009.
Runge CF, Senauer B (2007). How biofuels could starve the poor. Foreig. Aff. 86(3):41-53.
Saghaian SH (2010). The impact of the oil sector on commodity prices: correlation or causation?. J. Agric. Appl. Econ. 42(3):477-485.
von Braun J, Ahmed A, Okyere KA, Fan S, Gulati A, Hoddinott J (2008). High food prices: the what, who, and how of proposed policy actions. Washington IFPRI, Policy Brief, May 2008. http://www.ifpri.org/sites/default/files/publications/foodpricespolicyaction.pdf
Yu TE, Bessler DA, Fuller S (2006). Cointegration and causality analysis of world vegetable oil and crude oil prices. California Am. Agric. Econ. Assoc. Ann. Meet. July 23-26.
Zhang Q, Reed M (2008). Examining the impact of the world crude oil price on China's agricultural commodity prices: the case of corn, soybean, and pork. Dallas South. Agric. Econ. Assoc. Ann. Meet. February 2-5.
Zhang Z, Lohr L, Escalante C, Wetzstein M (2009). Ethanol, corn and soybean price relations in a volatile vehicle-fuels market. Energies 2(2):320-339.

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