ANALYSIS OF RURAL YOUTH INVOLVEMENT IN COMMERCIAL MOTORCYCLE OPERATION IN ILORIN EAST LOCAL GOVERNMENT AREA OF KWARA STATE, NIGERIA

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ABSTRACT

This study examines the implications of occupational migration of rural youth from farming to commercial motorcycle operation in Ilorin East Local Government Area of Kwara State. Data for the study were obtained through the administration of structured questionnaire. Twelve settlements with sizeable number of commercial motorcycle operators were purposively selected from which a total of 120 respondents were randomly selected for the study. The data was analyzed using frequency counts, percentages, mean ranking and the Chi-square statistical techniques. Results show that 57.5% of the operators were between 21-30 years old and have been frustrated out of farming by lack of access to agricultural credit, poor access to modern inputs, and other factors that result in low returns from farming. On the other hand, the stable income and relatively higher freedom in commercial motorcycle operation attract people into the occupation. The implications include reduction in area of land cultivated, lower productivity and reduced income from farming. Recommendations made include training the youth in modern farming techniques and introduction of appropriate policy measures to make agricultural loans easily accessible to people in rural areas.

Key words: Agricultural labour, Commercial Motorcycle, Migration, Rural, Youth

INTRODUCTION

Agriculture is the backbone of the economy of most African countries and the main source of income for about 90% of rural dwellers on the continent (United Nations Economic and Social Council (UNESCO), 2007). It is also the major source of employment in rural areas of Nigeria and was contributing about 70 - 80% of the total value of Nigeria's exports before the discovery of petroleum in commercial quantities (Angba, 2003). Despite the fact that Nigeria is richly blessed with great agricultural potentials, the contribution of agriculture to the economy has sharply declined over the years. For example, the agricultural sector which provided 76% of the county's foreign exchange earnings in 1970 accounted for only 14% of external earnings in 1992 (Ohajianya, 2005). Today the Nigerian agricultural sector has remained undeveloped and still dominated by peasant farmers using traditional technologies and depending mostly on family labour (Adegeye, 1995; Oluyole and Egbetokun, 2009).

Despite the fact that the larger proportion of Nigerians still reside in the countryside, the rural areas are characterized by low standard of living, low level of education, lack of access to standard social amenities and low income among other problems (Olomola, 2003; Olayiwola;

Adeloye and Akinola, 2007). The increasing level of disparity in development and opportunities for income between the rural and urban areas has resulted in selective out migration of young people from rural areas. On the other hand, decreasing availability of young, energetic population in rural areas has left farming in the hands of the elderly, young children and the small population of youth left in the villages (Adebayo, 1999; Echebiri and Mbanasor, 2003). The importance of human labour to the predominantly smallholder farmers in Nigeria cannot be overemphasized (Echebiri and Mbanasor, 2003). Labour is an essential factor in farming in a developing economy like Nigeria. The availability of labour has been found to have impact on planting precision, better weed control, timely harvesting and crop processing (Oluyole and Egbetokun 2009). In view of the importance of labour in agriculture, manpower from active youths is needed in the improvement of the agricultural sector. While farm labour is not homogeneous, farming operations generally differ as the men performed the heavier work like land clearing and the women and children participate in planting, fertilizer application and weeding (Nweke, 1980 and Echebiri, 2003). Evidence has shown that available labour force comprised mostly of old people to the exclusion of young men and women within the active working age had a negative impact on agricultural productivity (Uwaka 1982).

The emergence of commercial motorcycle operation in Nigeria can be traced to the early 1970s. However, the use of motorcycle for commercial services rapidly grew with the massive retrenchment of civil servants in the mid 1970s (Ogunsanya and Galtima, 1993; Adesanya, 1998). Commercial motorcycles are popularly known as "Okada", "Achaba", "Going", "Express" and various other local names in different parts of the country. The use of motorcycles for commercial transport services which was more or less restricted to urban centres has become very popular in rural areas in recent times. Today, unemployment and underemployment has forced many people to exploit the regular income and casual employment opportunities in okada riding, which is found to be dominated by youth below the age of 30 years (Ogunrinola, 2011).

While the commercial motorcycle has eased the transport difficulties of many people, its operation has many negative impacts in the country. For instance, it has been linked to high rate of accidents, armed robbery, increasing air pollution from carbon emission and negative impacts on labour supply for artisan trades (Olubomehin, 2012). Previous studies on the effects of commercial motorcycle operation have focused on the urban environment (Ogunsanya and Galtima, 1993; Adesanya, 1998; Ogunrinola, 2011and Olubomehin, 2012). On the other hand some researchers have examined the effects of rural urban migration on supply of agricultural labour (Nweke, 1980; Echibiri and Mbanasor, 2003 and Ohajianya, 2005). However, no previous study in Kwara State in particular has focused on the implications of rural youth migration from agriculture to commercial motorcycle operation. This is the gap in knowledge that this study seeks to fill. In addition any study that helps to identify factors pushing rural youth from agricultural production to other occupations is justified. This study will also highlight the need to develop the agricultural sector and help motivate youth to take more active part in agricultural production. The general objective of the study is to examine the implications of the occupational migration of rural youth from farming to commercial motorcycle operation. The specific objectives are to: examine the socio-economic characteristics of those involved in commercial motorcycle operation in the area; identify the factors influencing youth migration from farming to commercial motorcycle operation and, determine the effects of withdrawal of farm labour to commercial motorcycle operation in the area. The hypothesis posited is that there is no significant relationship between the commercial motorcycle operators' participation in agricultural activities and their involvement in commercial motorcycle (Okada) operation.

STUDY AREA

The research was carried out in Ilorin East Local Government Area (LGA) of Kwara State, Nigeria. Oke Oyi the LGA headquarter is located about 16 kilometers from Ilorin the State capital. The LGA (Fig.1) is located between Latitudes 8° and 15° N and Longitudes 4° and 5° E and shares boundary with Ilorin South, Ilorin West, Moro and Ifelodun LGAs (Kwara State Government, 2013). Ilorin East LGA lies within the Tropical wet and dry climate with the wet season stating around the end of March and ending in October and the dry season lasts from November to February.

The area is mainly covered by ferruginous and crystalline acid soils that have good potentials for the production of large variety of crops. The major rivers in the area are Asa, Oyun, Agba and Alalubosa. In 2006, the LGA had a population of 207,462 (Federal Republic of Nigeria Official Gazette, 2009). Major occupation of the people in the rural part of the area is farming. Some of the important agricultural products are maize, sorghum, cassava, yams, soyabean, locust bean, and milk (Kwara State Government, 2008 and Raw Material Research and Development Council, 2009). Major tribes in the area are Yoruba and Fulani.

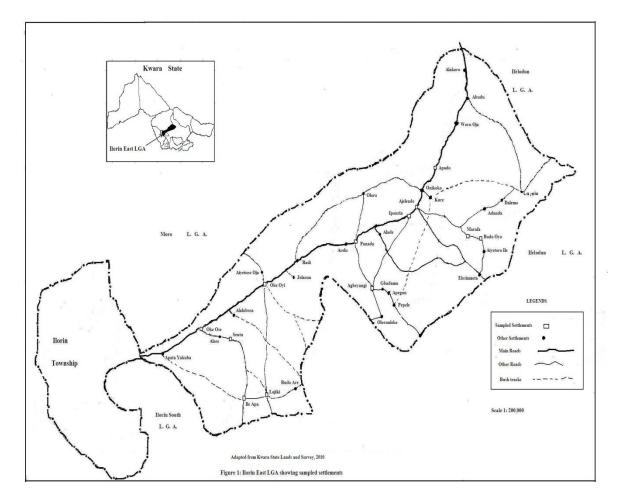


Figure 1: Ilorin East LGA showing sampled settlements Source: Adapted from Kwara State Lands and Survey, 2010

MATERIALS AND METHODS

The data for the study were obtained through the administration of structured questionnaire. In addition to socio-economic data and reasons for involvement in commercial motorcycle operation, personal data was also obtained on the effects of their involvement in motorcycle operation on farming activities. A reconnaissance survey of the study area was used to identify the settlements with sizeable number of commercial motorcycle operators who formed the target population. Based on this criterion twelve settlements were selected and most of them were found to be the larger villages with comparatively higher economic activities, while others are located at strategic road junctions. Ten motorcycle operators were then randomly selected from each of the selected settlements on the basis of their willingness to participate in the survey, to give a total of 120 respondents. The 12 selected rural settlements are: Oke Ose, Oke Oyi, Panada, Agbeyangi, Apapado, Iponrin, Marafa, Lajiki, Pepele, Ile Apa, Sentu and Ajelende (Figure 1).

The data was analyzed using frequency counts, percentages, likert scale and mean ranking. The Chi-square technique was also used to examine the factors associated with youth involvement in commercial motorcycle operation and its effect on agricultural production in the area.

RESULTS AND DISCUSSION

The distribution of the sampled respondents by their socio-economic characteristics shows that all the respondents are males supporting the fact that females are not engaged in the okada riding business. Also, 57.5% of the respondents fall within the age category of 21-30 years. Only 10% of them were above 40 years (Table 1). The result indicates that the youth are mostly involved in commercial motorcycle operation. Table 1 further show that about 31% of the respondents have been engaged in okada riding for 16 years and above, implying that many of the respondents have been in the business for a long time. These are in agreement with the findings of Ogunrinola (2011) that okada riding is dominated by youth below the age of 30 years and that many of them start riding motorcycle early in life, which makes it possible for them to take up okada riding as an occupation.

Table 1 further indicates that 58.3% of the respondents were married implying they have additional responsibilities that might have pushed them into okada riding. Only 35.8% of the respondents do not have above 5 persons in their households. Large number of mouths to feed may also encourage opting to move into another occupation with possibility of earning higher income like okada riding. Few of the respondents (5.8%) indicated not having any formal education while over 70% had secondary education or above. Being educated might have been a reason why many of the respondents look down upon farming as an occupation and prefer a casual employment (Okada riding) which they see as a transitory occupation. As regards the primary occupation of the respondents before going into okada operation, 52.5% indicated being farmers, 3.3% were traders while 19.1% were unemployed.

It is however, interesting to note that all the respondents agreed to have been involved in farming activities at one time or the other. This is an indication that many young and energetic people are moving out of farming and going into employments like okada riding which are less strenuous and provide quick income source. As rightly observed by Adesanya (1998) and

Table 1: Socio-economic characteristics of the respondents

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Characteristics	Frequency	Percentage					
Age (years)							
< 21	15	12.5					
21-30	69	57.5					
31-40	24	20.0					
Above 40	12	10.0					
Total	120	100					
Years of experience in okada							
0-5	20	16.7					
6-10	35	29.2					
11-15	28	23.3					
16 yrs and above	37	30.8					
Total	120	100					
Marital status	120	100					
Single	18	15.0					
Married	70	58.3					
Widowed	14	11.7					
Divorced	18	15.0					
Total	120	100					
Household size	42	25.0					
1-5	43	35.8					
6-10	46	38.4					
11 and above	31	25.8					
Total	120	100					
Educational status	_						
No formal education	7	5.8					
Primary education	26	21.7					
Secondary education	60	50.0					
Tertiary education	27	22.5					
Total	120	100					
Occupation before going into okada riding							
Farming	63	52.5					
Fishing	5	4.1					
Trading	4	3.3					
Civil servant	6	5.0					
Others	19	16.0					
Unemployed	23	19.1					
Total	120	100					
Ownership of the motorcycles							
Owned by the rider	95	79.2					
Not owned by the rider	25	20.8					
Total	120	100					
Average monthly income (Naira)							
< 5,000	17	14.2					
5,000–10,000	43	35.8					
10,001–15,000	28	23.3					
15,001–20,000	19	15.8					
Above 20,000	13	10.8					
Total	120	100					
10111	120	100					

Source: Field survey, 2011

Ogunrinola (2011) many young people are forced to exploit the income and casual employment opportunity in okada riding due to unemployment and underemployment.

As high as 79.2% of the respondents own the motorcycles they are riding. It can be deduced that the business is so lucrative that it allows the riders to save and purchase their own motorcycles. This is a form of encouragement for other youths to abandon farming and move into okada riding. This has the implication of further worsening the fortunes of the agricultural sector in the country. The average monthly earnings from the occupation were between \$45, 000 - \$10, 000 for 35.8% of the respondents. Another 23.3% earn \$10, 000 - \$15, 000 while 26.6% earn above \$15, 000 per month.

Factors influencing youth movement from farming to okada riding in Ilorin East LGA

Various factors were found to be responsible for the abandonment of farming by the respondents. As indicated in Table 2 poor storage facilities is ranked 1st as the most important factor pushing the youth out of farming in the area. This is not surprising because poor storage facilities force farmers to sell their farm produce at very low prices during the harvest season. For instance, it has been observed that African farmers receive only about 30-50% of final market prices for their products as a result of poor storage and poor transport facilities (Ahmed and Rustagi, 1987). Inadequate storage facilities also discourage the farmers from expanding their production even when they have the capacity and interest to do so.

Next in rank was low financial return from farming which has been attributable to problems of inadequate storage facilities, inefficient transport and distribution and poor access to credit in rural areas of the country (Ohajianya, 2005 and Ajiboye and Afolayan, 2009). Average labour wage rates are generally lower in agriculture than in non-agriculture (Bhaduri, 1999), which usually results in movement of labour to other sectors. Also, the low prestige attached to the farming profession and poor access to agricultural loans ranked 3rd and 4th respectively as factors pushing the youth out of farming.

Table 2: Factors influencing moveme	East LGA						
Factors	Strongly	Agree	Disagree	Strongly	Not	Mean	Rank
	Agree (%)	(%)	(%)	Disagree	Sure		
				(%)	(%)		
Poor storage facilities	59.2	40.0	0.8	0	0	3.59	1
Low financial returns from farming	59.2	36.7	4.2	0	0	3.55	2
Low prestige attached to farming	53.3	44.8	1.9	0	0	3.51	3
Poor access to credit	50.8	47.5	1.7	0	0	3.49	4
Poor processing skill	45.8	52.5	1.7	0	0	3.44	5
Poor yield from farm	48.3	47.5	4.2	0	0	3.43	6
Okada riding provides regular income	44.2	52.2	3.6	0	0	3.41	7
Farming is an energy sapping work	53.0	42.7	0	0	4.3	3.40	8
Poor access to farm tools and inputs	38.3	57.5	4.2	0	0	3.34	9
Allows greater social interaction and	34.2	35.0	30.8	0	0	3.04	10
freedom							

Source: Field survey, 2011

On the other hand, regular and quick financial returns from okada riding which is ranked 7th with a mean score of 3.41 was the most important pull factor. The regular income provided by okada riding is a major attraction for people seeking for means of escape from poverty through self employment (Adebayo, 1999). Although ranked 10th, the greater social interaction and freedom associated with okada operation also plays a role in attracting the youth to okada riding. This shows that for some of them opting to become okada riders go beyond the expected financial benefits from the occupation. This is because some view okada riding as an escape from the great physical demands of farming and the low prestige attached to farming as an occupation in Nigeria today. It means that the agricultural sector will continue to loose more of its young, able bodied and energetic people leaving the aged men and women and little children to manage the farms. Meanwhile, unavailability of labour could be a major constraint to peasant production (Gocowski and Oduwole, 2003) especially at sensitive periods in the farming season. The agricultural sector in the country is particularly noted to be dominated by small scale farmers using traditional technologies and depending largely on family labour (Adegeye, 1995 and Oluyole and Egbetokun, 2009).

Implications of youth withdrawal from farming

The result indicates that fathers of majority of the respondents (64.2%) were farmers (Table 3). Therefore these young men are expected to at least occasionally help out on the family farms. As expected some of the respondents indicated that they engaged in various farming activities like clearing of trees, planting, weeding, harvesting and marketing of farm produce.

Table 3: Respondents involvement in farming activities

Fathers' occupation	Frequency	Percentage
Farming	77	64.2
Fishing	15	12.5
Trading	12	10.0
Civil servant	13	10.8
Others	2	1.7
Total	120	100
Participation on parents' farms		
Regularly	16	13.4
Occasionally	31	25.8
Never	73	60.8
Total	120	100
Possession of personal farms		
Yes	43	35.8
No	77	64.2
Total	120	100
Intention of farming in the future		
Yes	47	39.2
Never	54	45.0
Undecided	19	15.8
Total	120	100

Source: Field survey, 2011

However, as seen in Table 3 only 13.4% indicated that their involvement in farming activities is regular. Another 25.8% indicated that they occasionally participate in farm work on their parents' farms. Their involvement in farming activities covers all areas of from work from clearing of trees to marketing of farm products. The remaining 60.8% of the respondents confirmed that they have not been helping on their parents' farms. Furthermore, as regards the ownership of personal farms only 35.8% owned farms. On the possibility of the respondents going back into farming in the near future only 39.2% indicated such interest. Many (45%) indicated that even if they leave the okada riding business they will never go back into farming but, will either migrate to the urban centres or go into some other occupation. This is a clear indication that most of the respondents have distanced themselves away from farming activities and are not likely to go back into farming in the near future.

Concerning their perception on the effects of their withdrawal from farming, increased pressure of work on the older generation (their parents) was ranked 1st. They agreed that most of the farm work is now left to the old men and women to undertake. These include strenuous activities like clearing of trees usually undertaken by young men in most areas. Reduced income from farm and low productivity were ranked 2nd and 3rd respectively. This is expected because the elderly and the young children left to undertake most of the farm work cannot be as productive as the energetic youth population. For instance, in a study in south eastern Nigeria, Echibiri (2003) found that farming households that depended primarily on the labour of children recorded less productivity.

Table 4: Perceived effects of youth withdrawal from farming

Effects	Strongly	Agree	Disagree	Strongly	Not	Mean	Rank
	Agree	(%)	(%)	Disagree	Sure		
	(%)			(%)	(%)		
Aged people are over-	50 (41.7)	21 (18.0)	29 (24.2)	16 (13.3)	4 (3.3)	2.83	1
stressed with work							
Reduced income	33 (27.0)	47 (39.2)	20 (16.7)	20 (16.7)	0(0)	2.78	2
Low productivity	31 (25.8)	37 (30.8)	34 (28.3)	11 (9.2)	7 (5.8)	2.62	3
Reduced farm size	35 (30.0)	9 (7.50)	55 (46.0)	19 (16.0)	1(0.8)	2.48	4
Use of underage	5 (4.2)	46 (38.3)	50 (42.0)	13 (11.0)	6 (5.0)	2.26	5
children for farming							
Hiring of more labour	18 (15.0)	25 (20.0)	50 (41.7)	20 (16.7)	7 (5.8)	2.23	6

Source: Field survey, 2011

Inability to cope with increasing pressure of farm work results in some of the farmers reducing the area of land cultivated. Reduction of farm size (ranked 4th) has the implication of further reducing farm output and income accruable to the farmers. However, some farmers resort to hiring of labour to do some of the farm work. This has the implication of raising the cost of production and with the possibility of reducing profits accruable to the farmers. The null hypothesis posited is that there is no significant relationship between the commercial motorcycle operators' participation in agricultural activities and their involvement in okada riding. This was subjected to Chi square analysis and the result presented in Table 5.

Table 5: Correlation results of commercial motorcycle operators' participation in agricultural activities and their involvement in okada riding

activities and their involvement in okada riding							
Variables	N	x	SD	df	Cal	Critical	Decision
					-value	value	
Participation	120	33.9	4.81	119	- 0.343	0.178	Rejected
in agricultural Activities							
Involvement in okada riding	120	69.59	4.56				

Level of significance = 0.01 Source: Field survey, 2011

Result of test of hypothesis on Table 5 shows that there is a significant relationship between the commercial motorcycle operators' participation in agricultural activities and their involvement in okada riding. This implies that youth participation in agricultural activities in the area has significantly reduced due to their involvement in okada riding. Therefore, continued movement of farm labour to commercial motorcycle riding occupation will further adversely affect the fortunes of the agricultural sector in the area.

RECOMMENDATIONS AND CONCLUSION

From the analysis it could be seen that commercial motorcycle occupation engaged many of the youth who would have otherwise been actively involved in agricultural production. Most of these young men are frustrated out of farming by the farm drudgery, lack of access to agricultural credit, poor access to modern inputs and tools, lack of storage facilities and other factors that result in low returns from farming. On the other hand, the stable income and relatively higher freedom in commercial motorcycle operation attracts them into the occupation. Deprived of the services of the young, energetic youth population the agricultural sector has to depend more on the labour of the aged and very young children. Other implications are reduction in area of land cultivated, lower productivity and reduced income from farming and increased poverty. The study recommends the following:

Agricultural youth development programmes should be made available in rural areas to train youths in modern farming techniques so as to improve their knowledge and make farming more attractive to them. Furthermore, appropriate policy measures should be introduced to make agricultural loans easily accessible to people in the rural areas. This will attract more people into farming and help stem the tide of migration from farming to other occupations and from rural to urban areas. Also, there is the need for government to embark on integrated rural development programmes that would radically transform the rural areas in the state. Apart from helping to improve the general level of wellbeing it would also, attract agro-allied industries that would further develop the agricultural sector.

REFERENCES

Adebayo, A. (1999) Youth Unemployment and the National Directorate of Employment Self Employment Programme. *The Nigerian Journal of Economics and Social Studies*, 41: 81-104

- Adegeye, A. J. (1995) Production and Marketing of Cocoa in Nigeria. In Adegeye, A. J. and W. O. Ajayi, (eds.) Cocoa Revolution in Nigeria. Proceedings of a National Seminar on Revolutionizing Nigeria's Cocoa Industry, 28-30th November, 1995, University of Ibadan.
- Adesanya, A. (1998) The Use of Motorcycles for Public Transportation in Nigeria: The situation in Ibadan, NISER Monograph Series, No. 6
- Ahmed, R. and Rustagi, N. (1987) Marketing and Price Incentive in African and Asian Countries: A Comparison. In Eltz, D. (ed.) *Agricultural Marketing Strategy and Pricing Policy*. Washington, D.C. World Bank.
- Ajiboye, A. O. and Afolayan, O. (2009) The Impact of Transportation on Agricultural Production in a Developing Country: A case Study of Kolanut Production in Nigeria. *International Journal of Agricultural Economics and Rural Development*, 2(2): 49-57
- Akinola, S. R. (2007) "Coping with Infrastructural Deprivation through Collective Action among Rural People in Nigeria". *Nordic Journal of African Studies* (16) 1: 30-46.
- Angba, A. O. (2003) Effects of Rural-Urban Migration of Youths on Agricultural Labour Supply in Umuahia North Local Government area of Abia State, Nigeria. *Journal of Agricultural Research*, 3(2): 77-83
- Echibiri, R. N. and Mbanasor, , J. A. (2003) Rural Age Distribution and Farm Labour Supply in Food Crop Production Systems in Abia State, Nigeria. *Tropical and Subtropical Agroecosystems*, 2(3): 129-136
- Federal Republic of Nigeria, Official Gazette (2009) Legal Notice on Publication of 2006 Census Final Results. Federal Government Printer. Abuja
- Kwara State Government (2008) *Diary*, 2008. Kwara State Ministry of Information and Home Affairs. Ilorin.
- Kwara State Government (2013) Ilorin East Local Government Area. http://www.kwarastate.gov.ng/ilorineast/
- Nweke, F. I. (1980) Farm Labour Problems of Smallholder Cropping Systems in Nigeria. Quarterly Journal of International Agriculture, 19: 257-288
- Ogunrinola, I. O. (2011) Informal Self-Employment and Poverty Alleviation: Empirical Evidence from Motorcycle Taxi Riders in Nigeria. *International Journal of Economics and Finance*, 3 (2):176-185
- Ogunsanya, A. A. and Galtima, M. (1993) "Motorcycle in Public Transport Service in Nigeria: A case of Yola Town" in Ikiya, S.G. (ed.) *Urban Passenger Transportation in Nigeria*. Heinemann Education Books. Ibadan. Pp. 190-207.

- Ohanjianya, D. O. (2005) Rural urban migration and effects on agricultural labour supply in Imo State, Nigeria. *International Journal of Rural development*, 6: 111-118
- Olayiwola, L. M. and Adeleye, O. A. (2005) Rural Infrastructural Development in Nigeria: Between 1960 and 1990 Problems and Challenges. *Journal of Social Sciences*,11(2) 91-96
- Olomola, A. S. (2003) "Understanding Poverty in Nigeria: Highlights from NISER Review of Nigerian Development". In *NISEREEL*, the magazine of the Nigerian Institute of Economic and Social Research, No. 4&5, December, 2003. Ibadan.
- Olubomehin, O. O. (2012) The Development and Impact of Motorcycles as Means of Commercial Transportation in Nigeria. *Research in Humanities and Social Sciences*, 2 (6): 231-239
- Oluyole, K. A. and Egbetokun, O. A. (2009) The Influence of Technological Changes on Labour Availability: A Case of Cocoa Farming Households in Ogun State, Nigeria. *Journal of American Science*, 5 (7): 1540-1543
- United Nations Economic and Social Council (UNESCO) (2007) *Africa Review on Report on Agriculture and Rural Development (Summary)*. Economic Commission for Africa, Fifth Meeting of the Africa Committee on Sustainable Development (ACSD-5)/ Regional Implementation Meeting(RIM) for CSD-16, Addis Ababa, 22-25 October, 2007.
- Uwaka, C. T. (1982) Cross-Cultural Diffusion of Adult Education: The role of Agricultural Extension Staff in East Central States of Nigeria. Ph.D Dissertation, University of British Columbia, Canada.